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**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	32430	Total Pages	119
First Named Inventor or Application Identifier			
Yasuaki Namura			
Express Mail Label No.	EL568431223US		

**APPLICATION ELEMENTS**

See MPEP chapter 600 concerning utility patent application contents.

1. ☒ Fee Transmittal Form  
(Submit an original, and a duplicate for fee processing)
2. ☒ Specification [Total Pages 105]  
(preferred arrangement set forth below)
- Descriptive title of the invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the invention
  - Brief Summary of the invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC 113) [Total Sheets 12]
4. Oath or Declaration [Total Pages 2]
- a. ☒ Newly executed (original or copy)
- b. ☐ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)  
(Note Box 5 below)
- i. ☐ **DELETION OF INVENTOR(S)**  
Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (useable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ☐ Microfiche Computer Program (Appendix)
7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)
- a. ☐ Computer Readable Copy
- b. ☐ Paper Copy (identical to computer copy)
- c. ☐ Statement verifying identity of above copies

**ACCOMPANYING APPLICATION PARTS**

8. ☒ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(b) Statement (when there is an assignee) ☒ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement (IDS)/PTO-1449 ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Return Receipt Postcard (MPEP 503)  
(Should be specifically itemized)
14. ☐ Small Entity ☐ Statement filed in prior application, Statement(s) Status still proper and desired
15. ☒ Certified Copy of Priority Document(s)  
(if foreign priority is claimed)
16. ☒ Other: Check for \$1,944.00

**17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:**
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**PATENT**

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Attorney Docket No. 32430

Assistant Commissioner for Patents  
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Sir:

Transmitted herewith for filing by other than a small entity is the patent application of:

Inventor: Yasuaki Namura

For: MULTIBAND DATA COMMUNICATION APPARATUS,  
COMMUNICATION METHOD OF MULTIBAND DATA  
COMMUNICATION APPARATUS, AND STORAGE  
MEDIUM

12 sheets of formal drawings are included.

An assignment of the invention to Matsushita Electric Industrial Co., Ltd. is included along with a Recordation Form Cover Sheet. Please record and return the assignment to the undersigned.

Priority is claimed under 35 U.S.C. §119 on the basis of the following foreign applications:

Japanese Patent Application No. Hei. 11-82514 Filed March 25, 1999

A certified copy of this application is enclosed.

"Express Mail" mailing label number EL568431223US

Date of Deposit 3/24/00

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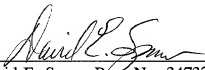
<u>For</u>	<u>Number</u>	<u>Rate</u>	<u>Fees</u>
Total claims in excess of 20:	14	× \$18.00	\$252.00
Independent claims in excess of 3:	9	× \$78.00	\$702.00
Multiple dependent claims, if any, add surcharge of \$260.00:			\$260.00
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		Basic Fee	\$690.00
		<b>TOTAL FILING FEE</b>	<b>\$1,904.00</b>
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The Commissioner is hereby authorized to charge any fees under 37 C.F.R. §§1.16 and 1.17 which may be required during the entire pendency of this application, or to credit any overpayment, to Deposit Account No. 16-0820, Order No. 32430.

Respectfully,

**PEARNE, GORDON, McCOY & GRANGER**

  
\_\_\_\_\_  
David E. Spaw, Reg. No. 34732

Date: March 24, 2000

**MULTIBAND DATA COMMUNICATION APPARATUS, COMMUNICATION METHOD OF  
MULTIBAND DATA COMMUNICATION APPARATUS, AND STORAGE MEDIUM**

BACKGROUND OF THE INVENTION

5           The present invention generally relates to a multiband  
data communication apparatus, a communication method of a  
multiband data communication apparatus, and a storage medium for  
storing a program used to execute the communication method of the  
multiband data communication apparatus. More specifically, the  
10   present invention is directed to a multiband data communication  
apparatus, a communication method of a multiband data  
communication apparatus, and a storage medium, capable of  
suppressing a circuit scale to a minimum circuit scale, and further  
capable of preventing a deterioration in a baseband signal.

15           As a conventional dual band data communication apparatus,  
or a conventional multiband data communication apparatus, one  
conventional data communication apparatus is represented in Fig.  
12. That is, Fig. 12 is an arrangement diagram of a conventional  
multiband data communication apparatus. In this case, as the data  
20   communication apparatus, such a data communication apparatus is  
conceived as a mobile communication apparatus typically known as  
a digital portable telephone and a paging receiver.

          This conventional multiband data communication apparatus  
is arranged by comprising an antenna 101, a local oscillator 104,  
25   a receiver unit, and a transmitter unit. In this apparatus, the

receiver unit is provided with an RF (radio frequency) amplifier 102, a downconverter 103, an intermediate frequency amplifier 105, a quadrature demodulator 1208, and a data output circuit 1221, whereas the transmitter unit is provided with a (high power) power amplifier 602, an upconverter 603, a quadrature modulator 1218, and a waveform generating circuit 1222. Referring now to the multiband data communication apparatus shown in Fig. 12, the conventional technique will be described.

First, in the receiver unit, a modulated reception signal which is received by the antenna 101 is amplified by the RF amplifier 102, and thereafter the amplified reception signal is entered into the downconverter 103. The downconverter 103 may output such signals having frequencies which are defined by adding the frequency of the amplified reception signal to a frequency of a local oscillation signal 152 outputted from the local oscillator 104, and also by subtracting the frequency of the amplified reception signal from the frequency of the local oscillation signal 152. In this case, it is now assumed that while using either a low-pass filter or a high-pass filter, the downconverter 103 selects as a reception intermediate frequency signal 151, a signal having such a subtraction frequency lower than the frequency of the received RF signal. The reception intermediate frequency signal 151 having the frequency lower than the frequency of the reception signal, which is outputted from the downconverter 103 is amplified by the intermediate frequency

amplifier 105. Then, the amplified intermediate frequency signal is entered into the quadrature demodulator 1208.

The quadrature demodulator 1208 is arranged by two sets of quadrature mixers 109 and 110, a reception local oscillator 111, and a phase shifter 1209. The quadrature mixers 109 and 110 convert the reception intermediate frequency signal into a reception baseband signal 157 and another reception baseband signal 158. The reception local oscillator 111 precisely outputs a signal having a carrier frequency equal to a central frequency of the reception intermediate frequency signal. The phase shifter 1209 produces two signals 157 and 158 whose phase difference is 90 degrees from the reception local signal, and then enters both the signals 157 and 158 into the quadrature mixers 109 and 110.

The quadrature demodulator 1208 enters thereinto the amplified reception intermediate frequency signal, and then outputs two sets of reception baseband signals 157 and 158 whose phase difference is 90 degrees. The data output circuit 1221 decodes reception data 159 by utilizing a phase relationship between the reception baseband signals 157 and 158 having the phase difference by 90 degrees from each other.

Next, a description will now be made of operations of the receiver unit having the quadrature demodulator 1208 equipped with the above-explained function.

In general, assuming now that orthogonal baseband signal

components are  $I(t)$  and  $Q(t)$ , and an angular frequency of a carrier wave is " $\omega_{RF}$ ", a reception signal  $SRF(t)$  may be expressed by the following formula (1):

$$SRF(t) = I(t)\cos[\omega_{RF}t] + Q(t)\sin[\omega_{RF}t] \quad \dots (1)$$

- 5 It should be noted that a coefficient of an amplitude which is equally applied to the respective terms of the below-mentioned formulae is negligible.

Also, assuming now that an angular frequency of a local oscillation signal is " $\omega_{L0}$ " and an arbitrary phase difference is " $\phi_{L0}$ ", an output signal " $SL0(t)$ " of the local oscillator 104 which is entered into the downconverter 103 is expressed by the following formula (2):

$$SL0(t) = \cos[\omega_{L0}t + \phi_{L0}] \quad \dots (2)$$

- 15 In the downconverter 103, the reception signal  $SRF(t)$  is multiplied by the local oscillation signal  $SL0(t)$ , so that an output  $SMIX(t)$  of the downconverter 103 is given by the following formula (3):

$$\begin{aligned} SMIX(t) &= SL0(t) \cdot SRF(t) \\ &= I(t) \{ \cos[(\omega_{L0} + \omega_{RF})t + \phi_{L0}] \\ &\quad + \cos[(\omega_{L0} - \omega_{RF})t + \phi_{L0}] \} \\ &\quad + Q(t) \{ \sin[(\omega_{L0} + \omega_{RF})t + \phi_{L0}] \\ &\quad + \sin[(\omega_{L0} - \omega_{RF})t + \phi_{L0}] \} \quad \dots (3) \end{aligned}$$

Also, since the term of " $\omega_{L0} + \omega_{RF}$ " of the output of the downconverter 103 corresponding to the high frequency component

is negligible in either the low-pass filter or the high-pass filter, when  $\omega L0 > \omega RF$ , the reception intermediate frequency signal  $SIF(t)$  (151) may be expressed by employing this angular frequency  $\omega IF$  ( $= \omega L0 - \omega RF$ ):

$$\begin{aligned} 5 \quad SIF(t) &= I(t)\cos[\omega IFt + \phi L0] \\ &\quad - Q(t)\sin[\omega IFt + \phi L0] \quad \dots(4) \end{aligned}$$

In the quadrature demodulator 1208, the reception baseband signals 157 and 158 are obtained by multiplying this reception intermediate frequency signal  $SIF(t)$  by the reception local oscillation signals 155 and 156 whose phase difference is 90 degrees. Assuming now that the reception baseband signals 157 and 158 correspond to "a(t)" and "b(t)", respectively, these baseband signals are expressed as follows:

$$\begin{aligned} a(t) &= SIF(t)\cos[\omega IFt + \phi IF] \\ 15 \quad &= I(t)\{\cos[2\omega IFt + \phi L0 + \phi IF] \\ &\quad + \cos[\phi L0 - \phi IF]\} \\ &\quad - Q(t)\{\sin[2\omega IFt + \phi L0 + \phi IF] \\ &\quad + \sin[\phi L0 - \phi IF]\} \quad \dots(5) \end{aligned}$$

In this case, since the baseband component is derived by neglecting the high frequency component, the reception baseband signal "a(t)" (157) is eventually given as:

$$a(t) = I(t)\cos[\phi BB] + Q(t)\sin[\phi BB] \quad \dots(6)$$

In this formula, it is assumed that  $\phi BB = \phi IF - \phi L0$ .



Similarly, since the other reception baseband signal "b(t)" is equal to  $SIF(t) \sin [\omega IFt + \emptyset IF]$ , this baseband signal "b(t)" is expressed as follows:

$$b(t) = I(t)\sin[\emptyset BB] + Q(t)\cos[\emptyset BB] \quad \dots(7)$$

- 5 While utilizing the quadrature characteristic of the signals, the respective components I(t) and Q(t) can be derived.

In this case, it is set that  $\omega L0 > \omega RF$ . However, such a frequency relationship cannot always be established in such a circuit arrangement capable of handling a plurality of frequency bands called as either "dual band" or "multiband". In other words, in a certain frequency band, the frequency relationship  $\omega L0 > \omega RF$  may be established and thus, the above-explained formulae can be calculated. However, considering now that another frequency relationship  $\omega L0 < \omega RF$  is established in another frequency band, since  $\omega IF = \omega RF - \omega L0$ , the following formulae are given as follows:

$$SIF2(t) = I(t)\cos[\omega IFt - \emptyset L0] + Q(t)\sin[\omega IFt - \emptyset IF] \quad \dots(10)$$

$$a2(t) = I(t)\cos[\emptyset BB2] - Q(t)\sin[\emptyset BB2] \quad \dots(11)$$

$$b2(t) = I(t)\sin[\emptyset BB2] - Q(t)\cos[\emptyset BB2] \quad \dots(12)$$

- 20 As a result, reception baseband signals whose phase relations are different from each other are obtained.

In such a case, in the data output circuit 1221, the polarities of the reception baseband signals 157 and 158 are switched by employing the band switching signal 153. As a result,

similar reception data 159 may be obtained.

On the other hand, in the transmitter unit, the waveform producing circuit 1222 into which transmission data 659 is inputted produces both a transmission baseband signal 657 and another transmission baseband 658, which may have a phase relationship in accordance with the entered transmission data 659.

Then, the waveform producing circuit 1222 enters the transmission baseband signals 657 and 658 to the quadrature modulator 1218.

The quadrature demodulator 1218 is arranged by two sets of quadrature mixers 609 and 610, a transmission local oscillator 611, and a phase shifter 1219, and also an adder 606. The quadrature mixers 609 and 610 convert the transmission baseband signals 657 and 658 into the intermediate frequency signals. The transmission local oscillator 611 precisely outputs a signal having a carrier frequency equal to a central frequency of the intermediate frequency signal. The phase shifter 1219 produces two signals 655 and 656 whose phase difference is 90 degrees from the transmission local signal, and then enters both the signals 655 and 656 into the quadrature mixers 609 and 610. The adder 606 adds two sets of intermediate frequency signals outputted from two sets of the quadrature mixers 609 and 610 to each other, and then outputs a transmission intermediate frequency signal.

The quadrature 1218 enters thereinto both the transmission baseband signals 657 and 658 which own a phase difference in accordance with the transmission data 659, and then

outputs a transmission intermediate frequency signal 651. The upconverter 603 outputs signals having frequencies obtained by adding and subtracting the frequency of the entered transmission intermediate frequency signal 651 and the frequency of the entered local oscillation signal 152. However, in this case, while employing either a high-pass filter or a band-pass filter, this up-converter 603 selects such a signal having a summation frequency higher than the original frequency as a transmission RF signal. The transmission RF signal derived from the upconverter 603 is amplified by the (high power) power amplifier 602, and then the amplified power transmission RF signal is outputted from the antenna 101 as the transmission signal.

Next, a description will now be made of operations of the transmitter unit including the quadrature modulator 1218 equipped with the above-explained function.

Generally speaking, in the waveform generating circuit 1222, assuming now that the transmission baseband signals 657 and 658 which own an orthogonal phase relationship between them and are produced from the transmission data 659 are expressed as an "I(t)" and a "Q(t)", respectively, and also an angular frequency of a local oscillation signal outputted from the transmission local oscillator 611 is equal to " $\omega_{IF}$ ", the transmission intermediate frequency signal 651 may be expressed as follows:

$$S_{IF}(t) = I(t)\cos[\omega_{IF}t] + Q(t)\sin[\omega_{IF}t] \quad \dots(18)$$

It should be noted that a coefficient of an amplitude equally

applied to the respective items is negligible.

In the upconverter 603, assuming now that the output signal of the upconverter 603 which is obtained by being multiplied by the output signal  $SL0(t)$  of the local oscillator 104 is equal to  $SMIX(t)$ , this transmission intermediate frequency signal 651 is given as follows:

$$\begin{aligned}
 SMIX(t) &= SL0(t) \cdot SIF(t) \\
 &= \cos[\omega L0 t - \phi L0] \\
 &\quad \times \{I(t)\cos[\omega IF t] + Q(t)\sin[\omega IF t]\} \\
 &= I(t)\{\cos[(\omega L0 - \omega IF)t + \phi L0] \\
 &\quad + \cos[(\omega L0 + \omega IF)t + \phi L0]\} \\
 &\quad + Q(t)\{\sin[(\omega L0 - \omega IF)t + \phi L0] \\
 &\quad - \sin[(\omega L0 + \omega IF)t + \phi L0]\} \quad \dots(19)
 \end{aligned}$$

Only such a desirable frequency component of the signal outputted from the upconverter 603 is selected. In the case that the local frequency is higher than the transmission frequency, assuming now that an angular frequency of a transmission signal  $SUL(t)$  is equal to  $\omega RF$  ( $= \omega L0 - \omega IF$ ), this transmission signal  $SUL(t)$  is given as follows:

$$\begin{aligned}
 SUL(t) &= I(t)\cos[\omega RF t + \phi L0] \\
 &\quad - Q(t)\sin[\omega RF t + \phi L0] \quad \dots(20)
 \end{aligned}$$

However, in such a case that the local frequency is higher than the transmission frequency, the angular frequency of the transmission signal becomes  $\omega RF = \omega L0 + \omega IF$ , and thus this

transmission signal  $SLL(t)$  is given as follows:

$$\begin{aligned} SLL(t) = & I(t)\cos[\omega Rft + \phi L0] \\ & -Q(t)\sin[\omega Rft + \phi L0] \end{aligned} \quad \dots(21)$$

As a result, this transmission signal  $SLL(t)$  may become a different  
5 transmission signal, depending upon the frequency relationship  
between the transmission signal and the local signal.

Accordingly, in such a case, in the waveform generating  
circuit 1222, the polarities of the reception baseband signals  
657 and 658 are switched by employing the band switching signal  
10 153, and furthermore, for instance, " $Q(t)$ " is replaced by " $-Q(t)$ "  
in the above-explained formula, so that a similar transmission  
signal can be obtained.

However, in the circuit arrangement of the above-  
explained conventional multiband data communication apparatus  
15 for switching the polarity of the baseband signal, a large circuit  
scale requirement is further made as to both the data output  
circuit 1221 and the waveform generating circuit 1222 which  
originally own the large circuit blocks. Moreover, there is  
another problem that since such a circuit is additionally provided,  
20 the signal quality of such a low-noise baseband signal would be  
deteriorated.

#### SUMMARY OF THE INVENTION

The present invention has been made to solve the  
above-described problems, and therefore, has an object to provide  
25 a multiband data communication apparatus, and a communication

method of a multiband data communication apparatus, capable of suppressing a circuit scale of an additionally provided circuit to a minimum circuit scale, which is suitably constituted in an integrated circuit form, while switching a plurality of frequency bands in response to a band switching signal and furthermore, while a deterioration in a baseband signal is avoided. Another object of the present invention is to provide a storage medium for storing thereinto a computer readable program used to execute the communication method of the multiband data communication apparatus.

To solve the above-described problems, a multiband data communication apparatus, according to first aspect of the present invention, receives signals by switching a plurality of frequency bands in response to a band switching signal, and includes quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, the quadrature demodulating means comprising: a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal; local oscillating means for producing a local oscillation signal; and phase shifting means for shifting a phase of the local oscillation signal based upon the band switching signal to thereby supply the phase-shifted local oscillation signal to the first quadrature mixers.

A multiband data communication apparatus, according to second aspect of the invention, transmits signals by switching a plurality of frequency band in response to a band switching signal, and includes quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, the quadrature modulating means is comprising: a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; local oscillating means for producing a local oscillation signal; and phase shifting means for shifting a phase of the local oscillation signal based upon the band switching signal to thereby supply the phase-shifted local oscillation signal to the second quadrature mixers.

A multiband data communication apparatus, according to third aspect of the present invention, includes quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal; quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal; and local oscillation signal producing means for supplying a local oscillation signal to both the quadrature modulating means and the quadrature demodulating means, for transmitting/receiving by switching a plurality of frequency

bands in response to a band switching signal, in that the quadrature demodulating means includes a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal; the quadrature modulating means includes a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and the local oscillation signal producing means includes local oscillating means for producing a local oscillation signal and phase shifting means for shifting a phase of the local oscillation signal based upon the band switching signal to thereby supply the phase-shifted local oscillation signal to the first quadrature mixer and the second quadrature mixer.

Preferably, in the multiband data communication apparatus according to the above-mentioned first, second, or third aspects of the invention, the phase shifting means supplies a signal obtained by shifting the phase of the local oscillation signal by  $\pi/2$  to one of the first quadrature mixers and the second quadrature mixers, while the phase shifting means supplies one of the local oscillation signal and a signal obtained by inverting a code of the local oscillation signal to the other of the first quadrature mixers and the second quadrature mixers in response to the band switching signal.

Preferably, in the multiband data communication



apparatus according to the above-mentioned first, second and third aspects of the invention, the phase shifting means supplies the local oscillation signal to one mixer of the first quadrature mixers and the second quadrature mixers, while the phase shifting means supplies one of a signal obtained by shifting the phase of the local oscillation signal by  $\pi/2$  and a signal obtained by shifting the phase of the local oscillation signal by  $\pi/2$  and by inverting the phase-shifted local oscillation signal to the other mixer of the first quadrature mixers and the second quadrature mixers in response to the band switching signal.

Preferably, in the multiband data communication apparatus according to the above-mentioned first, second and third aspects of the invention, the phase shifting means supplies the local oscillation signal to one of the first quadrature mixers and the second quadrature mixers, while the phase shifting means supplies one of a signal obtained by delaying the phase of the local oscillation signal by  $\pi/2$  and a signal obtained by advancing the phase of the local oscillation signal by  $\pi/2$  to the other mixer of the first quadrature mixers and the second quadrature mixers in response to the band switching signal.

Further, a multiband data communication apparatus according to fourth aspect of the invention, receives signals by switching a plurality of frequency bands in response to a band switching signal and includes quadrature demodulating means for converting either a reception signal or a reception intermediate

frequency signal into a quadrature reception baseband signal, the quadrature demodulating means comprising: a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception  
5 baseband signal; storage means for saving thereinto discrete data of a frequency pattern component functioning as a base; address generating means for generating an address every preselected clock; phase shift means for adding a predetermined number based upon the band switching signal to the address; first analog  
10 converting means for analog-converting data which is read out by addressing the storage means based on the address outputted from the address generating means to thereby supply the analog-converted data to one of the first quadrature mixers; and second analog converting means for analog-converting data which is read  
15 out by addressing the storage means based on the output of the phase shift means to thereby supply the analog-converted data to the other of the first quadrature mixers.

Further, a multiband data communication according to fifth aspect of the invention, transmits signals by switching a  
20 plurality of frequency band in response to a band switching signal, and includes quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, the quadrature modulating means comprising: a pair of  
25 second quadrature mixers for converting a transmission baseband

signal into either the transmission signal or the transmission intermediate frequency signal; storage means for saving thereinto discrete data of a frequency pattern component functioning as a base; address generating means for generating an address every  
5 preselected clock; phase shift means for adding a predetermined number based upon the band switching signal to the address; first analog converting means for analog-converting data which is read out by addressing the storage means based on the address outputted from the address generating means to thereby supply the  
10 analog-converted data to one of the second quadrature mixers; and second analog converting means for analog-converting data which is read out by addressing the storage means based on the output of the phase shift means to thereby supply the analog-converted data to the other of the second quadrature mixers.

15 Further, a multiband data communication apparatus according to sixth aspect of the invention, comprises: quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal; quadrature  
20 demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal; and local signal producing means for supplying a local oscillation signal to both the quadrature modulating means and the quadrature demodulating means, for  
25 transmitting/receiving by switching a plurality of frequency

bands in response to a band switching signal, in that the quadrature demodulating means includes a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal;

- 5 a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and the local oscillation signal producing means includes: storage means for saving thereinto discrete data of a frequency pattern component
- 10 functioning as a base; address generating means for generating an address every preselected clock; phase shift means for adding a predetermined number based upon the band switching signal to the address; first analog converting means for analog-converting data which is read out by addressing the storage means based on
- 15 the address outputted from the address generating means to thereby supply the analog-converted data to one of the first and second quadrature mixers; and second analog converting means for analog-converting data which is read out by addressing the storage means based on the output of the phase shift means to thereby supply
- 20 the analog-converted data to the other of the first and second quadrature mixers.

Preferably, in a multiband communication apparatus according to the above-mentioned fourth, fifth and sixth aspects of the invention, either the quadrature modulating means or the

25 local oscillation signal producing means includes: clock

According to seventh aspect of the invention, a communication method of a multiband data communication apparatus including quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, for receiving by switching a plurality of frequency bands in response to a band switching signal, in that the communication method comprises: a local oscillating step for producing a local oscillation signal; a phase shifting step for shifting a phase of the local oscillation signal in response to the band switching signal to thereby supply the phase-shifted local oscillation signal to a first quadrature mixer for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal.

According to the eighth aspect of the invention, a communication method of a multiband data communication apparatus including quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, for transmitting by switching a plurality of frequency band in response to a band switching signal, in that the communication method is comprised of: a local oscillating step for producing a local oscillation

signal; and a phase shifting step for shifting a phase of the local oscillation signal in response to the band switching signal to thereby supply the phase-shifted local oscillation signal to a second quadrature mixer for converting a transmission baseband  
5 signal into either the transmission signal or the transmission intermediate frequency signal.

According to the ninth aspect of the invention, a communication method of a multiband data communication apparatus including quadrature modulating means for converting a quadrature  
10 transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal; and quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal; and for transmitting/receiving by  
15 switching a plurality of frequency bands in response to a band switching signal, in that the communication method comprises: a local oscillating step for producing a local oscillation signal; and a phase shifting step for shifting a phase of the local oscillation signal in response to the band switching signal to  
20 thereby supply the phase-shifted local oscillation signal to one of a first quadrature mixer and a second quadrature mixer, the first quadrature mixer converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal, and the second quadrature mixer converting a  
25 transmission baseband signal into either the transmission signal

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or the transmission intermediate frequency signal.

Preferably, in the communication method according to the above-mentioned seventh, eighth, and ninth aspects of the invention, the phase shifting step includes: a first supplying  
5 step for supplying a signal which is obtained by shifting the phase of the local oscillation signal by  $\pi/2$  to one of the first quadrature mixers and the second quadrature mixers; an inverting step for inverting a code of the local oscillation signal; and a second supplying step for supplying one of the local oscillation  
10 signal and the output signal of the inverting step to the other of the first quadrature mixers and the second quadrature mixers in response to the band switching signal.

Preferably, in the communication method according to the above-mentioned seventh, eighth, and ninth aspects of the phase  
15 shifting step includes: a first supplying step for supplying the local oscillation signal to one of the first quadrature mixers and the second quadrature mixers; a phase shifting step for shifting the phase of the local oscillation signal by  $\pi/2$ ; an  
20 inverting step for inverting a code of the output signal of the phase shifting step; and a second supplying step for supplying one of the output signal of the phase shifting step and the output signal of the inverting step to the other of the first quadrature mixers and the second quadrature mixers in response to the band switching signal.

Preferably, in the communication method according to the

above-mentioned seventh, eighth, and ninth aspects of the invention, the phase shifting step includes: a first supplying step for supplying the local oscillation signal to one of the first quadrature mixer and the second quadrature mixer; a phase delaying  
5 step for delaying the phase of the local oscillation signal by  $\pi/2$ ; a phase advancing step for advancing the phase of the local oscillation signal by  $\pi/2$ ; and a second supplying step for supplying one of the output signal of the phase delaying step and the output signal of the phase advancing step to the other of the  
10 first quadrature mixer and the second quadrature mixer in response to the band switching signal.

According to tenth aspect of the invention, a communication method of a multiband data communication apparatus including quadrature demodulating means for converting either a reception  
15 signal or a reception intermediate frequency signal into a quadrature reception baseband signal, for receiving by switching a plurality of frequency bands in response to a band switching signal, in that the communication method is comprised of: a storing step for saving thereinto discrete data of a frequency pattern  
20 component functioning as a base; an address generating step for generating an address every preselected clock; a phase shifting step for adding a predetermined number based upon the band switching signal to the address; a first analog converting step for analog-converting data which is read out by addressing the  
25 storing step based on the address outputted from the address



generating step to thereby supply the analog-converted data to one of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal; and a second analog converting step  
5 for analog-converting data which is read out by addressing the storing step based on the output of the phase shifting step to thereby supply the analog-converted data to the other of the first quadrature mixers.

According to eleventh aspect of the invention, a  
10 communication method of a multiband data communication apparatus including quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, for transmitting by switching a plurality of frequency band in response to a band  
15 switching signal, in that the communication method is comprised: a storing step for saving therein discrete data of a frequency pattern component functioning as a base; an address generating step for generating an address every preselected clock; a phase shifting step for adding a predetermined number based upon the  
20 band switching signal to the address; a first analog converting step for analog-converting data which is read out by addressing the storing step based on the address outputted from the address generating step to thereby supply the analog-converted data to one of second quadrature mixers for converting a transmission  
25 baseband signal into either the transmission signal or the

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the reception signal or the reception intermediate frequency signal into a reception baseband signal, and a second quadrature mixer converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and a second analog converting step for analog-converting data which is read out by addressing the storing step based on the output of the phase shifting step to thereby supply the analog-converted data to the other of the first quadrature mixers and the second quadrature mixers.

Furthermore, a storage medium, according to the invention, is a storage medium for storing therein a computer readable program used to execute the communication method of the multiband data communication apparatus as mentioned above.

In the multiband data communication apparatus according to first aspect of the invention, the communication method of the multiband data communication apparatus according to seventh aspect of the invention, when a plurality of frequency bands are switched by the band switching signal to receive the communication data, the local oscillation signal is produced by the local oscillating means (local oscillating step), and the phase of the local oscillation signal is changed in response to the band switching signal by the phase shifting means (phase shifting step).

Then, the phase-shifted local oscillation signal is supplied to the first quadrature mixer for converting either the reception signal or the reception intermediate frequency signal into the

reception baseband signal.

As a result, the correct reception baseband signal is obtained not depending upon the frequency band, but a desirable reception baseband signal can be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal, and then the correct demodulating process operation can be carried out in accordance with the band switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element (processing step). The increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, as compared with the conventional arrangement in which the polarity of the reception baseband signal itself is switched by the data output circuit. Therefore, such an arrangement may be suitably formed in an integrated circuit. Furthermore, since the correct demodulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal, the deterioration of the reception baseband signal can be avoided. To the contrary, conventionally, the reception baseband signal is directly processed to invert the code polarities of the quadrature components.

In the multiband data communication apparatus according to second aspect of the invention, and the communication method of the multiband data communication apparatus according to eight

aspect of the invention, when a plurality of frequency bands are switched by the band switching signal to transmit the communication data, the local oscillation signal is produced by the local oscillating means (local oscillating step), and the phase of the local oscillation signal is changed in response to the band switching signal by the phase shifting means (phase shifting step). Then, the phase-shifted local oscillation signal is supplied to the second quadrature mixer for converting the transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal.

As a result, the correct transmission signal is obtained not depending upon the frequency band, but a desirable transmission signal, or a desirable transmission intermediate frequency signal can be obtained irrespective of the frequency relationship between the transmission signal and the local oscillation signal, and then the correct modulating process operation can be carried out in accordance with the band switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element (processing step). The increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, as compared with the conventional arrangement in which the polarity of the transmission baseband signal itself is switched by the waveform generating circuit. Therefore, such an arrangement may be

suitably formed in an integrated circuit. Furthermore, since the correct demodulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal, the deterioration of the transmission baseband signal can be avoided. To the contrary, conventionally, the transmission baseband signal is directly processed to invert the code polarities of the quadrature components.

In the multiband data communication apparatus according to third aspect of the invention, the communication method of the multiband data communication apparatus according to ninth aspect of the invention, when a plurality of frequency bands are switched by the band switching signal to transmit/receive the communication data, the local oscillation signal is produced by the local oscillating means (local oscillating step), and the phase of the local oscillation signal is changed in response to the band switching signal by the phase shifting means (phase shifting step). Then, the phase-shifted local oscillation signal is supplied to the first quadrature mixer for converting either the reception signal or the reception intermediate frequency signal into the reception baseband signal. Otherwise, this phase-shifted local oscillation signal is supplied to the second quadrature mixer for converting the transmission baseband signal to either the transmission signal or the transmission intermediate frequency signal.

As a result, the correct reception baseband signal and

the correct transmission signal can be obtained not depending upon the frequency band, but the correct modulating/demodulating process operations can be carried out in accordance with the band switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element (processing step) in the transmission system and the reception system. The increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, as compared with the conventional arrangement in which the polarity of the reception baseband signal itself is switched by the data output circuit, and also the polarity of the transmission baseband is switched by the waveform generating circuit. Therefore, such an arrangement may be suitably formed in an integrated circuit.

Furthermore, since the correct demodulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal, the deteriorations of the reception baseband signal and the transmission baseband signal can be avoided. To the contrary, conventionally, the reception baseband signal and also the transmission baseband signal are directly processed to invert the code polarities of the quadrature components.

More specifically, in the phase shifting means (phase shifting step), for example, the phase shifting means (first supplying step) supplies such a signal obtained by shifting the

phase of the local oscillation signal by  $\pi/2$  to one mixer of the first quadrature mixers and the second quadrature mixers; the code of the local oscillation signal is inverted by the inverting means (inverting step); and the switching means (second supplying step)

5 supplies any one of the local oscillation signal and the output signal of the inverting means (inverting step) in response to the band switching signal to the other of the first quadrature mixers and the second quadrature mixers. It should be noted that both the inverting means (inverting step) and the switching means

10 (second supplying step) may be realized by an exclusive OR gating means (exclusive OR gating step) for exclusively OR-gating the local oscillation signal and the binary signal produced based upon the band switching signal to thereby supply the exclusively OR-gated signal to the other of the first quadrature mixers and

15 the second quadrature mixers.

As explained above, as the structural element (processing step) used to perform the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal, only either the inverting means (inverting

20 step) and the switching means (second supplying step) or the exclusive OR gating means (exclusive OR gating step) is employed.

Therefore, the increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, and thus, such an arrangement may be suitably formed in

25 an integrated circuit.



More specifically, in the phase shifting means (phase shifting step), for example, the phase shifting means (first supplying step) supplies the local oscillation signal to one mixer of the first quadrature mixers and the second quadrature mixers; the phase shift means (phase shift step) shifts the phase of the local oscillation signal by  $\pi/2$ ; the code of the output signal of the phase shift means (phase shift step) is inverted by the inverting means (inverting step); and the switching means (second supplying step) supplies any one of the output signal of the phase shift means (phase shift step) and the output signal of the inverting means (inverting step) in response to the band switching signal to the other of the first quadrature mixers and the second quadrature mixers. It should be noted that both the inverting means (inverting step) and the switching means (second supplying step) may be realized by an exclusive OR gating means (exclusive OR gating step) for exclusively OR-gating the local oscillation signal and the binary signal produced based upon the band switching signal to thereby supply the exclusively OR-gated signal to either the other of the first quadrature mixers and the second quadrature mixers.

As explained above, as the structural element (processing step) used to perform the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal, only either the inverting means (inverting step) and the switching means (second supplying step) or the

exclusive OR gating means (exclusive OR gating step) is employed.

Therefore, the increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, and thus, such an arrangement may be suitably formed in an integrated circuit.

More specifically, in the phase shifting means (phase shifting step), for example, the phase shifting means (first supplying step) supplies the local oscillation signal to one of the first quadrature mixers and the second quadrature mixers; the phase delaying means (phase delaying step) delays the phase of the local oscillation signal by  $\pi/2$ ; the phase advancing means (phase advancing step) advances the phase of the local oscillation signal; and the switching means (second supplying step) supplies any one of the output signal of the phase delaying means (phase delaying step) and the output signal of the phase advancing means (phase advancing step) in response to the band switching signal to the other of the first quadrature mixers and the second quadrature mixer.

As explained above, as the structural element (processing step) used to perform the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal, only the phase advancing means (phase advancing step) and the switching means (second supplying step) are employed. Therefore, the increase in the additionally provided circuit scale (processing step) can be suppressed to the

minimum circuit scale, and thus, such an arrangement may be suitably formed in an integrated circuit.

Moreover, in the multiband data communication apparatus according fourth, fifth and sixth aspects of the invention, and

the communication method of the multiband data communication apparatus according to tenth, eleventh and twelfth aspects of the invention, when the communication data is transmitted/received by switching a plurality of frequency bands in response to the band switching signal, the discrete data of the frequency pattern

component functioning as a base is saved in the storage means (by storing step); the address generating means (address generating step) generates the address every preselected clock; the phase shift means (phase shift step) adds the predetermined number based upon the band switching signal to the address; the first analog converting means (first analog converting step) analog-converts the data which is read out by addressing the data saved in the storage means (storing step) based on the address outputted from the address generating means (address generating step) to thereby supply the analog-converted data to one of the first quadrature

mixers and the second quadrature mixers. The first quadrature mixer converts either the reception signal or the reception intermediate frequency signal into the reception baseband signal.

The second quadrature mixer converts the transmission baseband signal into either the transmission signal or the transmission

intermediate frequency signal. Also, the second analog

converting means (second analog converting step) analog-converts the data which is read out by addressing data saved in the storage means (storage step) in response to the output of the phase shift means (phase shift step), and thereafter supplies the analog-converted data to the other of the first quadrature mixers and the second quadrature mixers.

As previously explained, the structural element (processing step) additionally provided so as to execute the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal may be realized by, for example, a DDS (Direct Digital Synthesizer) and a DSP (Digital Signal Processor) and the like, which are additionally provided in the transmission system and the reception system. As a consequence, the increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale, as compared with the conventional arrangement in which the polarity of the transmission baseband signal is switched by the waveform generating circuit, and the polarity of the reception baseband signal is changed by the data output circuit. Therefore, such an arrangement may be suitably formed in an integrated circuit. Furthermore, since the correct demodulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal, the deteriorations of the reception baseband signal and the transmission baseband signal

can be avoided. To the contrary, conventionally, the transmission baseband signal and the reception baseband signal are directly processed to invert the code polarities of the quadrature components.

5 In the multiband data communication apparatus, in particular, the clock signal is generated by the clock generating means; and the clock interval at which the data is read out from the storage means is determined by the interval determining means so as to control the address generation by the address generating  
10 means. As a result, it is possible to arbitrarily control the frequency of the local oscillation signal generated from the local oscillation signal generating means, in the quadrature demodulating means, or the quadrature modulating means.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 Fig. 1 is a structural diagram of a multiband data communication apparatus according to a first embodiment mode of the present invention;

Fig. 2 is a structural diagram of a multiband data communication apparatus according to a second embodiment mode of  
20 the present invention;

Fig. 3 is a structural diagram of a multiband data communication apparatus according to a third embodiment mode of the present invention;

Fig. 4 is a structural diagram of a multiband data  
25 communication apparatus according to a fourth embodiment mode of

the present invention;

Fig. 5 is a structural diagram of a multiband data communication apparatus according to a fifth embodiment mode of the present invention;

5 Fig. 6 is a structural diagram of a multiband data communication apparatus according to a sixth embodiment mode of the present invention;

10 Fig. 7 is a structural diagram of a multiband data communication apparatus according to a seventh embodiment mode of the present invention;

Fig. 8 is a structural diagram of a multiband data communication apparatus according to an eighth embodiment mode of the present invention;

15 Fig. 9 is a structural diagram of a multiband data communication apparatus according to a ninth embodiment mode of the present invention;

Fig. 10 is a structural diagram of a multiband data communication apparatus according to a tenth embodiment mode of the present invention;

20 Fig. 11 is a structural diagram of a multiband data communication apparatus according to an eleventh embodiment mode of the present invention; and

Fig. 12 is a structural diagram of the conventional multiband data communication apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to drawings, a description will be made of various embodiment modes related to a multiband data communication apparatus, a communication method of a multiband data communication apparatus, and also a storage medium of the present invention, while sequentially explaining first to eleventh embodiment modes in detail in combination with modifications. It should be understood that in the descriptions of the respective embodiment modes, the multiband data communication apparatus and the communication method of the multiband data communication apparatus, according to the present invention, will be described in detail. However, since the storage medium according to the present invention is equal to such a storage medium for storing therein a program used to execute the above-described communication method of the multiband data communication apparatus, a description thereof is involved in the below-mentioned explanations as to the communication method of the multiband data communication apparatus.

(First Embodiment)

Fig. 1 is a structural diagram for indicating either a multiband data communication apparatus or a multiband data communication apparatus to which a communication method is applied, according to a first embodiment mode of the present invention. This first embodiment mode is such a multiband data communication apparatus for receiving by switching a plurality

of frequency bands in response to a band switching signal, namely is directed to a data communication apparatus such as a mobile communication apparatus which is typically known as a digital portable telephone and a paging receiver.

5 In Fig. 1, the multiband data communication apparatus, according to this first embodiment mode, is arranged by employing an antenna 101, an radio frequency amplifier 102, a downconverter 103, a local oscillator 104, an intermediate frequency amplifier 105, a quadrature demodulator 108, and also a data output circuit  
10 121. The antenna 101 is used to effectively receive a reception signal. The radio frequency (high frequency) amplifier 102 amplifies the received radio frequency signal under low noise condition. The downconverter 103 converts the radio frequency signal into an intermediate frequency signal 151. The local  
15 oscillator 104 oscillates a local oscillation signal 152 which is entered into the downconverter 103. The intermediate frequency amplifier 105 amplifies the intermediate frequency signal converted by the downconverter 103. The quadrature demodulator 108 converts the amplified intermediate frequency  
20 signal into both a reception baseband signal 157 and another reception baseband signal 158. The data output circuit converts the reception baseband signals 157 and 158 into reception data 159.

Also, in Fig. 1, the quadrature demodulator 108 is  
25 arranged by employing quadrature mixers (first quadrature mixers)

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109 and 110; a reception local oscillator (local oscillating means) 111; a phase shifter 112; an inverter circuit 113; and also a switch circuit 114. The quadrature mixers 109 and 110 convert the entered reception intermediate frequency signal into both the reception baseband signals 157 and 158. The reception local oscillator 111 oscillates a reception local oscillation signal (local oscillation signal) which is entered into the quadrature mixers 109 and 110. The phase shifter 112 shifts the phase of the reception local oscillation signal. The inverter circuit 113 inverts the code of the reception local oscillation signal. The switch circuit 114 selects that which reception local oscillation signal should be entered into the quadrature mixer 110 among a polarity of reception local oscillation signals having different phases from each other.

In this case, the phase shifter 112, the inverter circuit 113, and the switch circuit 114 correspond to a phase shifting means. The inverter circuit may be realized by an inverting amplifier and the like. The switch circuit 114 may be realized by an analog switch made of a switching element. Also, a DEC 107 additionally provided with the quadrature demodulator 108 corresponds to a decode for decoding the band switching circuit 153 to thereby produce a switching signal 154 of the switch circuit 114.

Generally speaking, in the multiband data communication apparatus equipped with the above-described arrangement,

assuming now that orthogonal baseband signal components are  $I(t)$  and  $Q(t)$ , and an angular frequency of a carrier wave is " $\omega_{RF}$ ", a reception signal  $SRF(t)$  received from the antenna 101 may be expressed by the following formula (1):

$$SRF(t) = I(t)\cos[\omega_{RF}t] + Q(t)\sin[\omega_{RF}t] \quad \dots (1)$$

It should be noted that a coefficient of an amplitude which is equally applied to the respective terms of the below-mentioned formulae is negligible.

Also, assuming now that an angular frequency of the local oscillation-signal 152 is " $\omega_{L0}$ " and an arbitrary phase difference is " $\phi_{L0}$ ", an output signal " $SL0(t)$ " of the local oscillator 104 which is entered into the downconverter 103 is expressed by the following formula (2):

$$SL0(t) = \cos[\omega_{L0}t + \phi_{L0}] \quad \dots (2)$$

In the downconverter 103, the reception signal  $SRF(t)$  is multiplied by the local oscillation signal  $SL0(t)$ , so that an output  $SMIX(t)$  of the downconverter 103 is given by the following formula (3):

$$\begin{aligned} SMIX(t) &= SL0(t) \cdot SRF(t) \\ &= \cos[\omega_{L0}t + \phi_{L0}] \\ &\quad \cdot \{I(t)\cos[\omega_{RF}t] + Q(t)\sin[\omega_{RF}t]\} \\ &= I(t) \{ \cos[(\omega_{L0} + \omega_{RF})t + \phi_{L0}] \\ &\quad + \cos[(\omega_{L0} - \omega_{RF})t + \phi_{L0}] \} \\ &\quad + Q(t) \{ \sin[(\omega_{L0} + \omega_{RF})t + \phi_{L0}] \\ &\quad - \sin[(\omega_{L0} - \omega_{RF})t + \phi_{L0}] \} \end{aligned}$$

$$-\sin[(\omega L0 - \omega RF)t + \phi L0] \} \quad \dots(3)$$

Also, since the term of " $\omega L0 + \omega RF$ " of the output of the downconverter 103 corresponding to the high frequency component is negligible in either the low-pass filter or the high-pass filter,

5 when  $\omega L0 > \omega RF$ , the reception intermediate frequency signal 151 may be expressed by employing this angular frequency  $\omega IF (= \omega L0 - \omega RF)$ :

$$\begin{aligned} SIF(t) &= I(t)\cos[\omega IFt + \phi L0] \\ &\quad - Q(t)\sin[\omega IFt + \phi L0] \end{aligned} \quad \dots(4)$$

10 In the quadrature demodulator 108, the reception baseband signals 157 and 158 are obtained by multiplying this reception intermediate frequency signal  $SIF(t)$  by the reception local oscillation signals 155 and 156 whose phase difference is 90 degrees. Assuming now that the reception baseband signals 157  
15 and 158 correspond to " $a(t)$ " and " $b(t)$ ", respectively, the first baseband signal " $a(t)$ " is expressed as follows:

$$\begin{aligned} a(t) &= SIF(t)\cos[\omega IFt + \phi IF] \\ &= \{I(t)\cos[\omega IFt + \phi L0] - Q(t)\sin[\omega IFt + \phi L0]\} \\ &\quad \cdot \cos[\omega IFt + \phi IF] \\ 20 \quad &= I(t)\{\cos[2\omega IFt + \phi L0 + \phi IF] \\ &\quad + \cos[\phi L0 - \phi IF]\} \\ &\quad - Q(t)\{\sin[2\omega IFt + \phi L0 + \phi IF] \\ &\quad + \sin[\phi L0 - \phi IF]\} \end{aligned} \quad \dots(5)$$

In this case, since the baseband component is derived by neglecting the high frequency component, the reception baseband signal "a(t)" is eventually given as:

$$a(t) = I(t)\cos[\phi_{BB}] + Q(t)\sin[\phi_{BB}] \quad \dots(6)$$

5 In this formula, it is assumed that  $\phi_{BB} = \phi_{IF} - \phi_{L0}$ .

Similarly, since the other reception baseband signal "b(t)" is equal to  $SIF(t) \sin[\omega_{IF}t + \phi_{IF}]$ , this baseband signal "b(t)" is expressed as follows:

$$b(t) = I(t)\sin[\phi_{BB}] + Q(t)\cos[\phi_{BB}] \quad \dots(7)$$

10 While utilizing the quadrature characteristic of the signals, the respective components I(t) and Q(t) can be derived.

For instance, if  $\cos[\phi_{BB}] = 1$ , then the baseband signals "a(t)" and "b(t)" are given as follows:

$$a(t) = I(t) \quad \dots\dots\dots(8)$$

15  $b(t) = - Q(t) \quad \dots\dots\dots(9).$

This is directly related to the orthogonal baseband signal itself.

In this case, it is set that  $\omega_{L0} > \omega_{RF}$ . However, such a frequency relationship cannot always be established in such a circuit arrangement capable of handling a plurality of frequency  
20 bands called as either "dual band" or "multiband". In other words, in a certain frequency band, the frequency relationship  $\omega_{L0} > \omega_{RF}$  may be established and thus, the above-explained formulae can be calculated. However, considering now that another frequency relationship  $\omega_{L0} < \omega_{RF}$  is established in another frequency band,

since  $\omega_{IF} = \omega_{RF} - \omega_{L0}$ , the following formulae are given as follows:

$$\begin{aligned} SIF2(t) &= I(t)\cos[\omega_{IF}t - \phi_{L0}] \\ &\quad + Q(t)\sin[\omega_{IF}t - \phi_{IF}] \quad \dots(10) \end{aligned}$$

$$a2(t) = I(t)\cos[\phi_{BB2}] - Q(t)\sin[\phi_{BB2}] \quad \dots(11)$$

$$5 \quad b2(t) = I(t)\sin[\phi_{BB2}] - Q(t)\cos[\phi_{BB2}] \quad \dots(12)$$

As a result, if  $\cos[\phi_{BB2}] = 1$ , then the baseband signals "a2(t)" and "b2(t)" are given as follows:

$$a2(t) = I(t) \quad \dots(13),$$

$$b2(t) = Q(t) \quad \dots(14).$$

10 Therefore, reception baseband signals whose phase relations are different from each other are obtained.

In such a case, in the quadrature demodulator 108, the polarity of the switch circuit 114 is switched by employing the band switching signal 153. As a result, the below-mentioned

15 formulae are given:

$$\begin{aligned} b2(t) &= SIF2(t)\{-\sin[\omega_{IF}t + \phi_{L0}]\} \\ &= \{I(t)\cos[\omega_{IF}t - \phi_{L0}] + Q(t)\sin[\omega_{IF}t - \phi_{L0}] \\ &\quad \cdot \{-\sin[\omega_{IF}t + \phi_{IF}]\} \\ &= \{-I(t)\sin[2\omega_{IF}t - \phi_{L0} + \phi_{IF}] + \sin[\phi_{L0} + \phi_{IF}]\} \\ 20 &\quad + \{Q(t)\cos[2\omega_{IF}t - \phi_{L0} + \phi_{IF}] + \cos[\phi_{L0} + \phi_{IF}]\} \\ &\quad \dots(15) \end{aligned}$$

In this formula, if the high frequency component, namely the term of  $2\omega_{IF}$  is neglected, then the baseband signal "b2(t)"

is given as follows:

$$b_2(t) = -I(t)\sin[\phi_{BB2}] - Q(t)\cos[\phi_{BB2}] \quad \dots(16)$$

If  $\cos[\phi_{BB2}] = 1$ , then it is given as follows:

$$b(t) = -Q(t) \dots\dots\dots(17)$$

- 5 As a consequence, the same reception baseband signals may be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal.

It should be noted that as a modification of this first embodiment mode, the phase shifter 112, the inverter circuit 113, and the switch circuit 114 employed in the quadrature demodulator 108 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, this modification is operated as follows:

- 15 At a first supplying step corresponding to the phase shifter 112, such a signal obtained by shifting the phase of the reception local oscillation signal by  $\pi/2$  is supplied via a D/A converter to the quadrature mixer 109. At an inverting step corresponding to the inverter circuit 113, the code polarity of the reception local signal is inverted. At a second supplying step corresponding to the switch circuit 114, any one of the reception local oscillation signal and the reception local oscillation signal inverted at the inverting step is switched in response to the band switching signal 153, and then the switched signal is supplied via a D/A converter
- 20 to the quadrature mixer 110.

As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this first embodiment mode, since the phase of the reception local oscillation signal is changed in response to the band switching signal 153, to thereby be supplied to both the quadrature mixers 109 and 110, the same reception baseband signal can be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal.

Moreover, in the quadrature demodulator 108, such a signal produced by shifting the phase of the reception local oscillation signal by  $\pi/2$  by the phase shifter 112 is supplied to the quadrature mixer 109. The switch circuit 114 supplies to the quadrature mixer 110, any one of the reception local oscillation signal which is switched in response to the band switching signal 153, and the reception local signal whose code polarity is inverted by the inverter circuit 113. As previously explained, only the inverter circuit 113 and the switch circuit 114 are employed as the structural elements which are additionally provided so as to execute the correct demodulating process operation in accordance with the band switching control by the band switching signal 153. As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit

arrangement that the polarity of the reception baseband signal itself is switched by the data output circuit.

Furthermore, since the correct demodulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal 153, the deteriorations of the reception baseband signals 157 and 158 can be avoided. To the contrary, conventionally, the reception baseband signal is directly processed to invert the code polarities of the quadrature components.

(Second Embodiment)

Next, Fig. 2 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a second embodiment mode of the present invention, is applied.

It should be noted that the same reference numerals shown in Fig. 1 (first embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted.

In the first embodiment mode, the phase of the reception local oscillation signal entered into the quadrature mixer 110 is switched so as to obtain the same reception baseband signals irrespective of the frequency relationship between the reception signal and the reception local oscillation signal. To achieve the same effect as that of the first embodiment mode, reception local oscillation signals whose phases are made different from



each other are entered into both the quadrature mixers 109 and 110, and furthermore, a phase relationship between these phases of the reception local oscillation signals is switched in response to the band switching signal 153. In other words, as to the 5 quadrature demodulator 108 employed in the first embodiment mode of Fig. 1, the quadrature demodulator of this second embodiment mode may be realized by changing the position of the phase shifter 112 into such a position (212) shown in Fig. 2.

Also, in Fig. 2, a quadrature demodulator 208 is arranged 10 by employing quadrature mixers (first quadrature mixers) 109 and 110; a reception local oscillator (local oscillating means) 111; a phase shifter 212; an inverter circuit 213; and also a switch circuit 214. The reception local oscillator 111 oscillates a reception local oscillation signal (local oscillation signal). 15 The phase shifter 212 shifts the phase of the reception local oscillation signal. The inverter circuit 213 inverts the reception local oscillating signal. The switch circuit 214 selects that which reception local oscillation signal should be entered into the quadrature mixer 110 among a plurality of 20 reception local oscillation signals having different phases from each other.

Similar to the first embodiment mode, it should be understood that as a modification of this second embodiment mode, the phase shifter 212, the inverter circuit 213, and the switch 25 circuit 214 employed in the quadrature demodulator 208 may be

arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, this modification is operated as follows:

5 At a first supplying step, the reception local oscillation signal is supplied via a D/A converter to the quadrature mixer 109. At a phase shift step corresponding to the phase shifter 212, the phase of the reception local signal is shifted by  $\pi/2$ . At an inverting step corresponding to the inverter circuit 213, the code  
10 polarity of the output signal of the phase shift step is inverted.

At a second supplying step corresponding to the switch circuit 214, any one of the output signal of the phase shift step and the output signal of the inverting step is switched in response to the band switching signal 153 to thereby be supplied via a D/A  
15 converter to the quadrature mixer 110.

As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this second embodiment mode, in the quadrature demodulator 208, the  
20 reception local oscillating signal is supplied to the quadrature mixer 109, and the switch circuit 214 switches the signal obtained by shifting the phase of the reception local oscillation signal by  $\pi/2$  by the phase shifter 212, or the signal produced by inverting the code polarity of the output signal from the phase shifter 212  
25 by the inverter circuit 213 in response to the band switching

00535303 032400

signal 153. Then, the switching circuit 214 supplies such a switched signal to the quadrature mixer 110. As previously explained, only the inverter circuit 213 and the switch circuit 214 are employed as the structural elements which are additionally provided so as to execute the correct demodulating process operation in accordance with the band switching control by the band switching signal 153. As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement that the polarity of the reception baseband signal itself is switched by the data output circuit. Also, similar to the first embodiment mode, there is such an effect that the deteriorations in the reception baseband signals 157 and 158 can be prevented.

(Third Embodiment)

Next, Fig. 3 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a third embodiment mode of the present invention, is applied. It should be noted that the same reference numerals shown in Fig. 1 (first embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. To achieve the same effect as that of the first embodiment mode, in a quadrature demodulator

308 according to this third embodiment mode, a switch circuit 314 switches an output signal derived from a phase shifter 312 and another output signal derived from another phase shifter 313, the phase change amounts of which are different from each other.

5           Also, in Fig. 3, the quadrature demodulator 308 is arranged by employing quadrature mixers (first quadrature mixers) 109 and 110, a reception local oscillator (local oscillating means) 111; the phase shifters 312 and 313; and also the switch circuit 314. The reception local oscillator 111 oscillates a  
10   reception local oscillation signal (local oscillation signal).

          The phase shifters 312 and 313 shift the phase of the reception local oscillation signal. The switch circuit 314 selects that which reception local oscillation should be entered into the quadrature mixer 110 among a polarity of reception local  
15   oscillation signals having different phases from each other.

          Similar to the first embodiment mode, it should also be noted that as a modification of this third embodiment mode, the phase shifters 312 and 313, and the switch circuit 314 employed in the quadrature demodulator 308 may be arranged by a DSP (digital  
20   signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

          In other words, at a first supplying step, the reception local oscillation signal is supplied via a D/A converter to the  
25   quadrature mixer 109, and at a phase delaying step corresponding

to the phase shifter 312, the phase of the reception local oscillation signal is delayed by  $\pi/2$ , whereas at a phase advancing step corresponding to the phase shifter 313, the phase of the reception local oscillation signal is advanced by  $\pi/2$ . Then, at a second supplying step corresponding to the switch circuit 314, any one of the output signal obtained at the phase delaying step and the output signal obtained at the phase advancing step is switched in response to the band switching signal 153 to thereby be supplied via a D/A converter to the quadrature mixer 110.

As previously explained, in the multiband data communication apparatus and the communication method of the multiband data communication apparatus, according to this third embodiment mode, in the quadrature demodulator 308, the reception local oscillation signal is supplied to the quadrature mixer 109.

The switch circuit 314 switches any one of the signal obtained by delaying the phase of the reception local oscillation signal by  $\pi/2$  by the phase shifter 312, and also the signal obtained by advancing the phase of the reception local signal by the phase shifter 313 in response to the band switching signal 153. Then, the switch circuit 314 supplies the selected signal to the quadrature mixer 110. As previously explained, only the phase shifter 313 and the switch circuit 314 are employed as the structural elements which are additionally provided so as to execute the correct demodulating process operation in accordance with the band switching control by the band switching signal 153.

As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement that the polarity of the reception baseband signal itself is switched by the data output circuit. Also, similar to the first embodiment mode, there is such an effect that the deteriorations in the reception baseband signals 157 and 158 can be prevented.

(Fourth Embodiment)

Next, Fig. 4 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a fourth embodiment mode of the present invention, is applied.

It should be noted that the same reference numerals shown in Fig. 1 (first embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. This fourth embodiment mode is featured by that in the quadrature demodulator 108 of the first embodiment mode, both the inverter circuit 113 and the switch circuit 114 are replaced by an exclusive OR gate circuit 413.

In Fig. 4, in a quadrature demodulator 408 according to this fourth embodiment mode, both a reception local oscillation signal and a decoded result (digital binary signal) 154 of a band switching signal 153 are entered into the exclusive OR gate circuit 413. In response to the value of the decoded result 154 of the

band switching signal, the exclusive OR gate circuit 413 inverts the reception local oscillation signal to output the inverted reception local oscillation signal to the quadrature mixer 110, or directly outputs the reception local oscillation signal to this  
5 quadrature mixer 110. As a result, even when such a circuit arrangement is employed, it is possible to achieve a similar effect to that of the first embodiment mode.

Similar to the first embodiment mode, it should also be understood that as a modification of this first embodiment mode,  
10 a phase shifter 412, and the exclusive OR gate circuit 413 employed in the quadrature demodulator 408 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP. That is to say, at a first supplying step  
15 corresponding to the phase shifter 412, such a signal obtained by shifting the phase of the reception local oscillation signal by  $\pi/2$  is supplied via a D/A converter to the quadrature mixer 109. At an exclusive OR-gating step corresponding to the exclusive OR gate circuit 413, such a signal obtained by  
20 exclusively OR-gating both the reception local oscillation signal and the decoded result 154 of the band switching signal 153 is supplied via a D/A converter to the quadrature mixer 110.

Also, similar to the modifications related to the first embodiment mode and the second embodiment mode, the position of  
25 the phase shifter 412 may be changed into such a position

(indicated by 212) shown in Fig. 2. Also, even when the circuit arrangement having such a changed structure is realized as processing steps of a program executed by the DSP, a similar effect may be apparently achieved.

5

(Fifth Embodiment)

Next, Fig. 5 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a fifth embodiment mode of the present invention, is applied. It should be noted that the same reference numerals shown in Fig. 1 (first embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. This fifth embodiment mode is featured by that a DDS is employed as a means for producing a reception local oscillation signal in a quadrature demodulator.

In Fig. 5, a quadrature demodulator 508 is arranged by employing: quadrature mixers (first quadrature mixers) 109 and 110 for converting a reception intermediate frequency signal into a reception baseband signal; memories 154 and 158 (storage means) for saving thereinto discrete data of a frequency pattern component functioning as a base; address generating units 513 and 516 for generating an address every preselected clock; a phase shift unit 517 for adding a predetermined number based upon the band switching signal 153 to the address so as to shift a phase; a D/A converting unit (first analog converting means) 515 for



analog-converting data which is read out by addressing the memory 513 based on the address outputted from the address generating unit 513 to thereby supply the analog-converted data to one set of the quadrature mixer 109; and another D/A converting unit (second analog converting means) 519 for analog-converting data which is read out by addressing the memory 518 based on the output of the phase shift unit 517 to thereby supply the analog-converted data to the quadrature mixer 110. The predetermined number is such a number used to advance a phase of a signal 156 by  $\pi/2$ , or to delay the phase of this signal 156 by  $\pi/2$ .

Also, the quadrature demodulator 508 is comprised of: a clock generating unit 511 for generating a clock signal; and an interval determining unit 512 for determining a clock interval "At" used to read out data from the memories 514 and 518 so as to control the address generating operation of the address generating units 513 and 516. Since this clock interval "At" of the interval determining unit 512 is set, the frequency of the produced reception local oscillation signal can be arbitrarily controlled. It should also be noted that a DEC 107 provided with the quadrature demodulator 508 is such a decoder which decodes the band switching signal 153 so as to produce a control signal 154 to the phase shift unit 517.

Similar to the first embodiment mode, it should be noted that as a modification of this fifth embodiment mode, the DDS portion except for the quadrature mixers 109 and 110 employed in

the quadrature demodulator 508 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

5 In other words, the communication method of the multiband data communication apparatus, according to the fifth embodiment, is realized by employing: a storing step for saving discrete data of a frequency pattern component functioning as a base into the memories 154 and 158; an address generating step for generating  
10 an address every preselected clock; a phase shifting step for adding a predetermined number based upon the band switching signal 153 to the address; a first analog converting step for analog-converting data which is read out by addressing the data saved in the memory 514 based on the address outputted from the  
15 address generating step to thereby supply the analog-converted data to the quadrature mixer 109; and a second analog converting step for analog-converting data which is read out by addressing the data saved in the memory 518 based on the output of the phase shifting step to thereby supply the analog-converted data to the  
20 quadrature mixer 110. The address generating step corresponds to the address generating units 513 and 516. The phase shifting step corresponds to the phase shifting unit 517. The predetermined number is such a number used to advance the phase of the signal 156 by  $\pi/2$ , or to delay the phase of this signal  
25 156 by  $\pi/2$ . The first analog converting step corresponds to the

D/A converting unit 515. The second analog converting step corresponds to the D/A converting unit 519.

As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this fifth embodiment mode, since the phase of the reception local oscillation signal is changed in response to the band switching signal 153 to thereby be supplied to the quadrature mixer 110, the same reception baseband signals can be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal.

Moreover, in the quadrature demodulator 508, the structural elements (processing steps) additionally provided so as to perform the correct demodulating process operation in accordance with the band switching control by receiving the band switching signal 153 may be realized by either the DDS or the DSP.

As a result, the increase in the additionally provided circuit scale (processing step) can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement. Also, similar to the first embodiment mode, there is such an effect that the deteriorations in the reception baseband signals 157 and 158 can be prevented.

(Sixth Embodiment)

Fig. 6 is a structural diagram for indicating either a

multiband data communication apparatus or a multiband data communication apparatus to which a communication method is applied, according to a sixth embodiment mode of the present invention. This sixth embodiment mode is such a multiband data communication apparatus for transmitting by switching a plurality of frequency bands in response to a band switching signal, namely is directed to a data communication apparatus such as a mobile communication apparatus which is typically known as a digital portable telephone.

In Fig. 6, the multiband data communication apparatus, according to this sixth embodiment mode, is arranged by employing an antenna 601, a power amplifier 602, an upconverter 613, a local oscillator 604, a quadrature modulator 608, and also a waveform generating circuit 621. The waveform generating circuit 621 converts transmission data 659 into transmission baseband signals 657 and 658 orthogonal to each other. The quadrature modulator 608 outputs a transmission intermediate frequency signal 651 which correspond to the entered transmission baseband signals 657 and 658. The local oscillator 604 produces a local oscillation signal 652. The upconverter 613 enters therein both the transmission intermediate frequency signal 651 and the local oscillation signal 652, and then outputs a transmission signal. The (high power) power amplifier 602 amplifies the transmission signal. The antenna 601 effectively transmits the amplified transmission signal.

Also, in Fig. 6, the quadrature modulator 608 is arranged by employing quadrature mixers (second quadrature mixers) 609 and 610; a transmission local oscillator (local oscillating means) 611; a phase shifter 612; an inverter circuit 613; and also a switch circuit 614. The quadrature mixers 609 and 610 convert the entered transmission baseband signals 657 and 658 into the transmission baseband intermediate frequency signals. [0102]

In this case, the phase shifter 612, the inverter circuit 613, and the switch circuit 614 correspond to a phase shifting means. The inverter circuit 613 may be realized by an inverting amplifier and the like. The switch circuit 614 may be realized by an analog switch made of a switching element. Also, a DEC 607 additionally provided with the quadrature modulator 608 corresponds to a decoder for decoding a band switching circuit 653 to thereby produce a switching signal 654 of the switch circuit 614.

In the multiband communication apparatus with employment of the above-explained circuit arrangement, generally speaking, in the waveform generating circuit 621, assuming now that the transmission baseband signals 657 and 658 which own an orthogonal phase relationship between them and are produced from the transmission data 659 are expressed as an "I(t)" and a "Q(t)", respectively, and also an angular frequency of a local oscillation signal outputted from the transmission local oscillator 611 is equal to " $\omega_{IF}$ ", the transmission intermediate frequency signal

651 may be expressed as follows:

$$SIF(t) = I(t)\cos[\omega IFt] + Q(t)\sin[\omega IFt] \quad \dots(18)$$

It should be noted that a coefficient of an amplitude equally applied to the respective items is negligible.

5           In the upconverter 603, assuming now that the output signal of the upconverter 603 which is obtained by being multiplied by the output signal  $SL0(t)$  of the local oscillator 604 is equal to  $SMIX(t)$ , this transmission intermediate frequency signal 651 is given as follows:

$$\begin{aligned} 10 \quad \underline{SMIX}(t) &= SL0(t) \cdot SIF(t) \\ &= \cos[\omega L0t + \varnothing L0] \\ &\quad \cdot \{I(t)\cos[\omega IFt] + Q(t)\sin[\omega IFt]\} \\ &= I(t) \{ \cos[(\omega L0 + \omega IF)t + \varnothing L0] \\ &\quad + \cos[(\omega L0 - \omega IF)t + \varnothing L0] \} \\ 15 \quad &+ Q(t) \{ \sin[(\omega L0 + \omega IF)t + \varnothing L0] \\ &\quad - \sin[(\omega L0 - \omega IF)t + \varnothing L0] \} \quad \dots(19) \end{aligned}$$

Only such a desirable frequency component of the signal outputted from the upconverter 603 is selected. In the case that the local frequency is higher than the transmission frequency, 20 assuming now that an angular frequency of a transmission signal  $SUL(t)$  is equal to  $\omega RF (= \omega L0 - \omega IF)$ , this transmission signal  $SUL(t)$  is given as follows:

$$\begin{aligned} SUL(t) &= I(t)\cos[\omega RFt + \varnothing L0] \\ &\quad - Q(t)\sin[\omega RFt + \varnothing L0] \quad \dots(20) \end{aligned}$$

However, in such a case that the local frequency is higher than the transmission frequency, the angular frequency of the transmission signal becomes  $\omega_{RF} = \omega_{L0} + \omega_{IF}$ , and thus this transmission signal  $SLL(t)$  is given as follows:

$$\begin{aligned} SLL(t) = & I(t)\cos[\omega_{RF}t + \phi_{L0}] \\ & + Q(t)\sin[\omega_{RF}t + \phi_{L0}] \quad \dots(21) \end{aligned}$$

As a result, this transmission signal  $SLL(t)$  may become a different transmission signal, depending upon the frequency relationship between the transmission signal and the local signal.

Accordingly, in such a case, in the quadrature modulator 608, while the switch circuit 614 is switched in response to the band switching signal 653, when the local oscillation signal inputted to the upconverter 603 is penetrated through a signal path involving the inverter circuit 613 for inverting the signal polarity, the transmission intermediate frequency signal 651 may be expressed as follows:

$$SIF(t) = I(t)\cos[\omega_{IF}t] - Q(t)\sin[\omega_{IF}t] \quad \dots(22)$$

The output signal  $SMIX(t)$  of the upconverter 603 is given as follows:

$$\begin{aligned} SMIX(t) = & SL0(t) \cdot SIF(t) \\ = & \cos[\omega_{L0}t + \phi_{L0}] \\ & \cdot \{I(t)\cos[\omega_{IF}t] - Q(t)\sin[\omega_{IF}t]\} \\ = & I(t)\{\cos[(\omega_{L0} + \omega_{IF})t + \phi_{L0}] \\ & + \cos[(\omega_{L0} - \omega_{IF})t + \phi_{L0}]\} \end{aligned}$$

$$+Q(t)\{\sin[(\omega_{L0}+\omega_{IF})t+\phi_{L0}]$$

$$-\sin[(\omega_{L0}-\omega_{IF})t+\phi_{L0}]\} \quad \dots(23)$$

Now, paying an attention to such a case that the local oscillation frequency is lower than the transmission frequency, since the angular frequency of this transmission signal is equal to  $\omega_{RF} = \omega_{L0} + \omega_{IF}$ , this transmission signal  $SLL(t)$  is given as follows:

$$SLL(t) = I(t)\cos[\omega_{RF}t + \phi_{L0}]$$

$$- Q(t)\sin[\omega_{RF}t + \phi_{L0}] \quad \dots(24)$$

As a consequence, it can be understood that the same transmission signal  $SLL(t)$  as that obtained when the local oscillation frequency is higher than the transmission frequency can be obtained.

It should be noted that as a modification of this sixth embodiment mode, the phase shifter 612, the inverter circuit 613, and the switch circuit 614 employed in the quadrature modulator 608 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, this modification is operated as follows:  
At a first supplying step corresponding to the phase shifter 612, such a signal obtained by shifting the phase of the transmission local oscillation signal by  $\pi/2$  is supplied via a D/A converter to the quadrature mixer 609. At an inverting step corresponding



to the inverter circuit 613, the code polarity of the transmission local signal is inverted. At a second supplying step corresponding to the switch circuit 614, any one of the transmission local oscillation signal and the transmission local oscillation signal inverted at the inverting step is switched in response to the band switching signal 653, and then the switched signal is supplied via a D/A converter to the quadrature mixer 610.

As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this sixth embodiment mode, since the phase of the transmission local oscillation signal is changed in response to the band switching signal 653, to thereby be supplied to both the quadrature mixers 609 and 610, the desirable transmission intermediate frequency signal can be obtained irrespective of the frequency relationship between the transmission signal and the local oscillation signal.

Moreover, in the quadrature modulator 608, such a signal produced by shifting the phase of the transmission local oscillation signal by  $\pi/2$  by the phase shifter 612 is supplied to the quadrature mixer 609. The switch circuit 614 supplies to the quadrature mixer 610, any one of the transmission local oscillation signal which is switched in response to the band switching signal 653, and the transmission local signal whose code polarity is inverted by the inverter circuit 613. As previously

explained, only the inverter circuit 613 and the switch circuit 614 are employed as the structural elements which are additionally provided so as to execute the correct modulating process operation in accordance with the band switching control by the band switching  
5 signal 653. As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement that the polarity of the transmission baseband signal itself is  
10 switched by the waveform generating circuit.

Furthermore, since the correct modulating process operation can be carried out in accordance with the band switching control by receiving the band switching signal 653, the deteriorations of the transmission baseband signals 657 and 658  
15 can be avoided. To the contrary, conventionally, the transmission baseband signal is directly processed to invert the code polarities of the quadrature components.

(Seventh Embodiment)

Next, Fig. 7 is a structural diagram of a multiband data  
20 communication apparatus to which either a multiband data communication apparatus or a communication method, according to a seventh embodiment mode of the present invention, is applied.

It should be noted that the same reference numerals shown in Fig. 6 (sixth embodiment mode) will be employed as those for denoting  
25 the same, or similar circuit elements of this drawing, and

descriptions thereof are omitted.

In the sixth embodiment mode, the phase of the transmission local oscillation signal entered into the quadrature mixer 610 is switched so as to obtain the desirable transmission intermediate frequency signal irrespective of the frequency relationship between the transmission signal and the transmission local oscillation signal. To achieve the same effect as that of the sixth embodiment mode, transmission local oscillation signals whose phases are made different from each other are entered into both the quadrature mixers 609 and 610, and furthermore, a phase relationship between these phases of the transmission local oscillation signals is switched in response to the band switching signal 653. In other words, as to the quadrature modulator 608 employed in the sixth embodiment mode of Fig. 6, the quadrature modulator of this seventh embodiment mode may be realized by changing the position of the phase shifter 112 into such a position (712) shown in Fig. 7.

Also, in Fig. 7, a quadrature modulator 708 is arranged by employing quadrature mixers (second quadrature mixers) 609 and 610; a transmission local oscillator (local oscillating means) 611; a phase shifter 712; an inverter circuit 713; and also a switch circuit 714. The transmission local oscillator 611 oscillates a transmission local oscillation signal (local oscillation signal). The phase shifter 712 shifts the phase of the transmission local oscillation signal. The inverter circuit 713

inverts the transmission local oscillating signal. The switch circuit 714 selects that which transmission local oscillation signal should be entered into the quadrature mixer 610 among a plurality of transmission local oscillation signals having  
5 different phases from each other.

Similar to the sixth embodiment mode, it should be understood that as a modification of this seventh embodiment mode, the phase shifter 712, the inverter circuit 713, and the switch circuit 714 employed in the quadrature modulator 708 may be  
10 arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, this modification is operated as follows:

At a first supplying step, the transmission local oscillation  
15 signal is supplied via a D/A converter to the quadrature mixer 609. At a phase shift step corresponding to the phase shifter 712, the phase of the transmission local signal is shifted by  $\pi/2$ .

At an inverting step corresponding to the inverter circuit 713, the code polarity of the output signal of the phase shift step  
20 is inverted. At a second supplying step corresponding to the switch circuit 714, any one of the output signal of the phase shift step and the output signal of the inverting step is switched in response to the band switching signal 653 to thereby be supplied via a D/A converter to the quadrature mixer 610.

25 As previously described, in accordance with the multiband

data communication apparatus and also the communication method of the multiband data communication apparatus, according to this seventh embodiment mode, in the quadrature modulator 708, the transmission local oscillating signal is supplied to the

5 quadrature mixer 609, and the switch circuit 714 switches the signal obtained by shifting the phase of the transmission local oscillation signal by  $\pi/2$  by the phase shifter 712, or the signal produced by inverting the code polarity of the output signal from the phase shifter 712 by the inverter circuit 713 in response to  
10 the band switching signal 653. As previously explained, only the inverter circuit 713 and the switch circuit 714 are employed as the structural elements which are additionally provided so as to execute the correct modulating process operation in accordance with the band switching control by the band switching signal 653.

15 As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit. Also, similar to the sixth embodiment mode, there is such an effect that the deteriorations in the transmission baseband signals 657 and 658  
20 can be prevented.

(Eighth Embodiment)

Next, Fig. 8 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to  
25 an eighth embodiment mode of the present invention, is applied.

It should be noted that the same reference numerals shown in Fig. 6 (sixth embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. To achieve the same effect as that of the sixth embodiment mode, in a quadrature modulator 808 according to this eighth embodiment mode, a switch circuit 814 switches an output signal derived from a phase shifter 812 and another output signal derived from another phase shifter 813, the phase change amounts of which are different from each other.

Also, in Fig. 8, the quadrature demodulator 808 is arranged by employing quadrature mixers (second quadrature mixers) 609 and 610, a transmission local oscillator (local oscillating means) 611; the phase shifters 812 and 813; and also the switch circuit 814. The transmission local oscillator 611 oscillates a transmission local oscillation signal (local oscillation signal). The phase shifters 812 and 813 shift the phase of the transmission local oscillation signal. The switch circuit 814 selects that which transmission local oscillation signal should be entered into the quadrature mixer 610 among a polarity of transmission local oscillation signals having different phases from each other.

Similar to the sixth embodiment mode, it should also be noted that as a modification of this eighth embodiment mode, the phase shifters 812 and 813, and the switch circuit 814 employed in the quadrature demodulator 808 may be arranged by a DSP (digital

signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, at a first supplying step, the  
5 transmission local oscillation signal is supplied via a D/A converter to the quadrature mixer 609, and at a phase delaying step corresponding to the phase shifter 812, the phase of the transmission local oscillation signal is delayed by  $\pi/2$ , whereas  
10 at a phase advancing step corresponding to the phase shifter 813, the phase of the transmission local oscillation signal is advanced by  $\pi/2$ . Then, at a second supplying step corresponding to the switch circuit 814, any one of the output signal obtained at the phase delaying step and the output signal obtained at the phase advancing step is switched in response to the band switching signal  
15 653 to thereby be supplied via a D/A converter to the quadrature mixer 610.

As previously explained, in the multiband data communication apparatus and the communication method of the multiband data communication apparatus, according to this eighth  
20 embodiment mode, in the quadrature modulator 808, the transmission local oscillation signal is supplied to the quadrature mixer 609. The switch circuit 814 switches any one of the signal obtained by delaying the phase of the transmission local oscillation signal by  $\pi/2$  by the phase shifter 812, and also  
25 the signal obtained by advancing the phase of the transmission

local signal by the phase shifter 813 in response to the band switching signal 653. Then, the switch circuit 814 supplies the selected signal to the quadrature mixer 610. As previously explained, only the phase shifter 813 and the switch circuit 814 are employed as the structural elements which are additionally provided so as to execute the correct modulating process operation in accordance with the band switching control by the band switching signal 653. As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement that the polarity of the transmission baseband signal itself is switched by the data output circuit. Also, similar to the sixth embodiment mode, there is such an effect that the deteriorations in the reception baseband signals 657 and 658 can be prevented.

(Ninth Embodiment)

Next, Fig. 9 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a ninth embodiment mode of the present invention, is applied. It should be noted that the same reference numerals shown in Fig. 6 (sixth embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. This ninth embodiment mode is featured by that in the quadrature modulator 608 of the sixth



embodiment mode, both the inverter circuit 613 and the switch circuit 614 are replaced by an exclusive OR gate circuit 913.

In Fig. 9, in a quadrature demodulator 908 according to this ninth embodiment mode, both a transmission local oscillation signal and a decoded result (digital binary signal) 654 of a band switching signal 653 are entered into the exclusive OR gate circuit 913. In response to the value of the decoded result 654 of the band switching signal, the exclusive OR gate circuit 913 inverts the transmission local oscillation signal to output the inverted transmission local oscillation signal to the quadrature mixer 610, or directly outputs the transmission local oscillation signal to this quadrature mixer 610. As a result, even when such a circuit arrangement is employed, it is possible to achieve a similar effect to that of the sixth embodiment mode.

Similar to the sixth embodiment mode, it should also be understood that as a modification of this ninth embodiment mode, a phase shifter 912, and the exclusive OR gate circuit 913 employed in the quadrature demodulator 908 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP. That is to say, at a first supplying step corresponding to the phase shifter 912, such a signal obtained by shifting the phase of the transmission local oscillation signal by  $\pi/2$  is supplied via a D/A converter to the quadrature mixer 609. At an exclusive OR-gating step corresponding to the

exclusive OR gate circuit 913, such a signal obtained by exclusively OR-gating both the transmission local oscillation signal and the decoded result 654 of the band switching signal 653 is supplied via a D/A converter to the quadrature mixer 610.

Also, similar to the modifications related to the sixth embodiment mode and the seventh embodiment mode, the position of the phase shifter 912 may be changed into such a position (indicated by 712) shown in Fig. 7. Also, even when the circuit arrangement having such a changed structure is realized as processing steps of a program executed by the DSP, a similar effect may be apparently achieved.

(Tenth Embodiment)

Next, Fig. 10 is a structural diagram of a multiband data communication apparatus to which either a multiband data communication apparatus or a communication method, according to a tenth embodiment mode of the present invention, is applied. It should be noted that the same reference numerals shown in Fig. 6 (sixth embodiment mode) will be employed as those for denoting the same, or similar circuit elements of this drawing, and descriptions thereof are omitted. This tenth embodiment mode is featured by that a DDS is employed as a means for producing a reception local oscillation signal in a quadrature demodulator.

In Fig. 10, a quadrature modulator 1008 is arranged by employing: quadrature mixers (second quadrature mixers) 609 and 610 for converting entered transmission baseband signals 657 and

15

25

the produced transmission local oscillation signal can be arbitrarily controlled. It should also be noted that a DEC 607 provided with the quadrature modulator 1008 is such a decoder which decodes the band switching signal 653 so as to produce a control  
5 signal 654 to the phase shift unit 617.

Similar to the sixth embodiment mode, it should be noted that as a modification of this tenth embodiment mode, the DDS portion except for the quadrature mixers 609 and 610 employed in the quadrature modulator 1008 may be arranged by a DSP (digital  
10 signal processor) and the like, and these circuit elements may be realized as processing steps of a computer program executed by this DSP.

In other words, the communication method of the multiband data communication apparatus, according to the tenth embodiment,  
15 is realized by employing: a storing step for saving discrete data of a frequency pattern component functioning as a base into the memories 1014 and 1018; an address generating step for generating an address every preselected clock; a phase shifting step for adding a predetermined number based upon the band switching signal  
20 653 to the address; a first analog converting step for analog-converting data which is read out by addressing the data saved in the memory 1014 based on the address outputted from the address generating step to thereby supply the analog-converted data to the quadrature mixer 609; and a second analog converting  
25 step for analog-converting data which is read out by addressing

the data saved in the memory 1018 based on the output of the phase shifting step to thereby supply the analog-converted data to the quadrature mixer 610. The address generating step corresponds to the address generating units 1013 and 1016. The phase shifting  
5 step corresponds to the phase shifting unit 1017. The predetermined number is such a number used to advance the phase of the signal 656 by  $\pi/2$ , or to delay the phase of this signal 656 by  $\pi/2$ . The first analog converting step corresponds to the D/A converting unit 1015. The second analog converting step  
10 corresponds to the D/A converting unit 1019.

As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this tenth embodiment mode, since the phase of the transmission local  
15 oscillation signal is changed in response to the band switching signal 653 to thereby be supplied to the quadrature mixer 610, the desirable transmission intermediate frequency signal can be obtained irrespective of the frequency relationship between the transmission signal and the local oscillation signal.

Moreover, in the quadrature modulator 1008, the structural elements (processing steps) additionally provided so as to perform the correct modulating process operation in  
20 accordance with the band switching control by receiving the band switching signal 653 may be realized by either the DDS or the DSP.

As a result, the increase in the additionally provided circuit  
25

scale (processing step) can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement.

Also, similar to the sixth embodiment mode, there is such an effect that the deteriorations in the transmission baseband signals 657 and 658 can be prevented.

(Eleventh Embodiment)

Fig. 11 is a structural diagram for indicating either a multiband data communication apparatus or a multiband data communication apparatus to which a communication method is applied, according to an eleventh embodiment mode of the present invention. It should be understood that the same reference numerals shown in the prior art (Fig. 12), the fourth embodiment mode (Fig. 4), and the ninth embodiment mode (Fig. 9) will be employed as those for denoting the same circuit elements shown in the drawing. This eleventh embodiment mode is directed to such a multiband data communication apparatus for transmitting/receiving communication data by switching a plurality of frequency bands in response to a band switching signal, and is featured by that both the fourth embodiment mode and the ninth embodiment mode are applied to a receiver unit and a transmitter unit provided in such a multiband data communication apparatus.

In Fig. 11, the multiband data communication apparatus, according to this eleventh embodiment mode, is arranged by an

antenna 101, a local oscillator 104, a receiver unit, a transmitter unit, and also a local oscillation signal generating unit. In this case, the receiver unit is equipped with a radio frequency (high frequency) amplifier 102, a downconverter 103, an  
5 intermediate frequency amplifier 105, a quadrature demodulator 408', and a data output circuit 121. The transmitter unit is equipped with a (high power) power amplifier 602, an upconverter 603, a quadrature modulator 609', and a waveform generating circuit 621.

10 Also, the local oscillation signal generating unit is so arranged as to commonly circuit portions capable of generating a local oscillation signal supplied to two sets of quadrature mixers in the quadrature demodulator 408 of the fourth embodiment mode, and the quadrature modulator 609 of the ninth embodiment  
15 mode. This local oscillation signal generating unit is provided with a local oscillator (local oscillating means) 111, a phase shifter 412, an exclusive OR gate circuit 413, and a decoder (DEC) 107. In this case, both the phase shifter 412 and the exclusive OR gate circuit 413 correspond to a phase shifting means.

20 In other words, such a signal produced by shifting a phase of a local oscillation signal of the local oscillator 111 by the phase shifter 412 by  $\pi/2$  is supplied to one mixer of the quadrature mixers 109 and 609. While the local oscillation signal and the decoded result 154 by the decoder 107 by the band switching signal  
25 153 are inputted to the exclusive OR gate circuit 413, either the

signal obtained by inverting the local oscillation signal or the non-inverted local oscillation signal in accordance with the value of the decoded result 154 of the band switching signal 153 is supplied to the other mixer of the quadrature mixers 109 and 609. As a result, the local oscillation signals having the respective frequencies suitable for the respective frequency bands may be outputted to the respective quadrature mixers, so that both the quadrature demodulator 408' and the quadrature modulator 609' may be operated in the correct manner.

First, in the receiver unit, a modulated reception signal which is received by the antenna 101 is amplified by the RF amplifier 102, and thereafter the amplified reception signal is entered into the downconverter 103. The downconverter 103 may output such signals having frequencies which are defined by adding the frequency of the amplified reception signal to a frequency of a local oscillation signal 152 outputted from the local oscillator 104, and also by subtracting the frequency of the amplified reception signal from the frequency of the local oscillation signal 152. In this case, for instance, while using either a low-pass filter or a high-pass filter, the downconverter 103 selects as a reception intermediate frequency signal 151, a signal having such a subtraction frequency lower than the frequency of the received RF signal. The reception intermediate frequency signal 151 having the frequency lower than the frequency of the reception signal, which is outputted from the downconverter



103 is amplified by the intermediate frequency amplifier 105.

Then, the amplified intermediate frequency signal is entered into the quadrature demodulator 408'.

The quadrature demodulator 408' is arranged by two sets  
5 of quadrature mixers 109 and 110. The quadrature mixers 109 and 110 convert the reception intermediate frequency signal into a reception baseband signal 157 and another reception baseband signal 158. The quadrature mixers 109 and 110 enter thereinto the amplified reception intermediate frequency signal, and the  
10 output signal 155 of the phase shifter 412, and also the output signal 156 of the exclusive OR gate circuit 413, and then output two sets of reception baseband signals 157 and 158 whose phase difference is 90 degrees. The data output circuit 121 decodes reception data 159 by utilizing a phase relationship between the  
15 reception baseband signals 157 and 158 having the phase difference by 90 degrees from each other.

On the other hand, in the transmitter unit, the waveform producing circuit 621 into which transmission data 659 is inputted produces both a transmission baseband signal 657 and another  
20 transmission baseband 658, which may have a phase relationship in accordance with the entered transmission data 659. Then, the waveform producing circuit 621 enters the transmission baseband signals 657 and 658 to the quadrature modulator 609'.

The quadrature modulator 609' is arranged by two sets of  
25 quadrature mixers 609 and 610, and also an adder 606. The

quadrature mixers 609 and 610 convert the transmission baseband signals 657 and 658 into the intermediate frequency signals. The adder 606 adds two sets of intermediate frequency signals outputted from two sets of the quadrature mixers 609 and 610 to each other, and then outputs a transmission intermediate frequency signal 651. In other words, two sets of the transmission baseband signals 657 and 658 which own the phase difference in accordance with the transmission data 659, the output signal 655 of the phase shifter 412, and the output signal 656 of the exclusive OR gate circuit 413 are inputted to both the quadrature mixers 609 and 610, so that the transmission intermediate frequency signals are outputted from these quadrature mixers 609 and 610.

The upconverter 603 outputs signals having frequencies obtained by adding and subtracting the frequency of the entered transmission intermediate frequency signal 651 and the frequency of the entered local oscillation signal 152. For example, in this case, while employing either a high-pass filter or a band-pass filter, this upconverter 603 selects such a signal having a summation frequency higher than the original frequency as a transmission RF signal. The transmission RF signal derived from the upconverter 603 is amplified by the (high power) power amplifier 602, and then the amplified power transmission RF signal is outputted from the antenna 101 as the transmission signal.

It should also be understood that as a modification of

this eleventh embodiment mode, the phase shifter 412 of the local oscillation signal generating unit, and the exclusive OR gate circuit 413 may be arranged by a DSP (digital signal processor) and the like, and these circuit elements may be realized as  
5 processing steps of a computer program executed by this DSP.

That is to say, at a first supplying step corresponding to the phase shifter 412, such a signal obtained by shifting the phase of the local oscillation signal by  $\pi/2$  is supplied via a D/A converter to one mixer of the quadrature mixers 109 and 609.

10 At an exclusive OR-gating step corresponding to the exclusive OR gate circuit 413, such a signal obtained by exclusively OR-gating both the local oscillation signal and the decoded result 154 of the band switching signal 153 is supplied via a D/A converter to the other mixer of the quadrature mixers 110 and 610.

15 As previously described, in accordance with the multiband data communication apparatus and also the communication method of the multiband data communication apparatus, according to this eleventh embodiment mode, since the phase of the local oscillation signal is changed in response to the band switching signal 153  
20 to thereby be supplied to the quadrature mixers 109 and 110 and also 609 and 610, the same reception baseband signal can be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal. Furthermore, a desirable transmission intermediate frequency signal can be  
25 obtained irrespective of the frequency relationship between the

transmission signal and the local oscillation signal.

Moreover, in the local oscillation signal generating unit, such a signal produced by shifting the phase of the local oscillation signal by  $\pi/2$  by the phase shifter 412 is supplied

5 to one mixer of the quadrature mixers 109 and 609. The switch circuit supplies to the other mixer of the quadrature mixers 110 and 610 from the exclusive OR gate circuit 413, any one of the local oscillation signal which is switched in response to the band switching signal 153, and the local oscillation signal whose code

10 polarity is inverted. As previously explained, only the exclusive OR gate circuit 413 is employed as the structural elements which are additionally provided so as to execute the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal 153.

15 As a result, the increase in the additionally provided circuit scale can be suppressed, and also the entire circuit arrangement can be suitably formed in an integrated circuit, as compared with such a conventional circuit arrangement that the polarity of the reception baseband signal itself is switched by the data output

20 circuit. Also, the polarity of the transmission baseband signal itself is switched by the waveform generating circuit.

Furthermore, since the correct modulating/demodulating process operations can be carried out in accordance with the band switching control by receiving the band switching signal 153, the

25 deteriorations of the baseband signals can be avoided. To the

contrary, conventionally, the baseband signal is directly processed to invert the code polarities of the quadrature components.

In the above-explained arrangement according to this  
eleventh embodiment mode, while the same sort of embodiment modes  
(namely fourth and ninth embodiment modes) are applied to the  
receiver unit and the transmitter unit respectively, the common  
structural portions (i.e., local oscillator 111, phase shifter  
412, exclusive OR gate circuit 413, and decoder 107) are commonly  
used by the local oscillation signal generating unit.

Alternatively, the same sorts of other combined embodiment modes  
(namely, first and sixth embodiment modes; second and seventh  
embodiment modes; and third and eighth embodiment modes) may be  
applied to the receiver unit and the transmitter unit,  
respectively.

Further, although the commonly operable circuit  
arrangement is limited to the local oscillator 111 and the decoder  
107, different sorts of combined embodiment modes may be  
alternatively realized. For instance, the first embodiment mode  
may be applied to the receiver unit whereas the seventh embodiment  
mode may be applied to the transmitter unit. Moreover, even in  
such an arrangement that the same sort of combined embodiment mode  
is applied to the receiver unit and the transmitter unit, as the  
common arrangement portion, both the local oscillator 111 and the  
decoder 107 may be provided, whereas the respective elements for

While the multiband data communication apparatus, the communication method of the multiband data communication

As a result, a desirable reception baseband signal can be obtained irrespective of the frequency relationship between the reception signal and the local oscillation signal, and then the correct demodulating process operation can be carried out in accordance with the band switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element (processing step).

The increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale. Therefore, such an arrangement may be suitably formed in an

integrated circuit. Furthermore, the deterioration of the reception baseband signal can be avoided, although conventionally the reception baseband signal is directly processed to invert the code polarities of the quadrature components.

5 In the multiband data communication apparatus, the communication method, and the storage medium, according to the present invention, when a plurality of frequency bands are switched by the band switching signal to transmit the communication data, the local oscillation signal is produced by  
10 the local oscillating means (local oscillating step), and the phase of the local oscillation signal is changed in response to the band switching signal by the phase shifting means (phase shifting step). Then, the phase-shifted local oscillation signal is supplied to the second quadrature mixer for converting  
15 the transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal. As a result, a desirable transmission signal, or a desirable transmission intermediate frequency signal can be obtained irrespective of the frequency relationship between the  
20 transmission signal and the local oscillation signal, and then the correct modulating process operation can be carried out in accordance with the band switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element  
25 (processing step). The increase in the additionally provided

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circuit scale (processing step) can be suppressed to the minimum circuit scale. Therefore, such an arrangement may be suitably formed in an integrated circuit. Furthermore, the deterioration of the transmission baseband signal can be avoided, although  
5 conventionally the transmission baseband signal is directly processed to invert the code polarities of the quadrature components.

Also, in accordance with the present invention, when a plurality of frequency bands are switched by the band switching  
10 signal to transmit/receive the communication data, the local oscillation signal is produced by the local oscillating means (local oscillating step), and the phase of the local oscillation signal is changed in response to the band switching signal by the phase shifting means (phase shifting step). Then, the phase-  
15 shifted local oscillation signal is supplied to the first quadrature mixer for converting either the reception signal or the reception intermediate frequency signal into the reception baseband signal. Otherwise, this phase-shifted local oscillation signal is supplied to the second quadrature mixer for  
20 converting the transmission baseband signal to either the transmission signal or the transmission intermediate frequency signal. As a result, the correct reception baseband signal and the correct transmission signal can be obtained not depending upon the frequency band, but the correct modulating/demodulating  
25 process operations can be carried out in accordance with the band



switching control by the band switching signal. To this end, only the phase shifting means (phase shifting step) is additionally provided as the structural element (processing step) in the transmission system and the reception system. The increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale. Therefore, such an arrangement may be suitably formed in an integrated circuit.

Furthermore, the deteriorations of the reception baseband signal and the transmission baseband signal can be avoided, although conventionally the reception baseband signal and also the transmission baseband signal are directly processed to invert the code polarities of the quadrature components.

Also, in accordance with the present invention, as the structural element (processing step) used to perform the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal, only either the inverting means (inverting step) and the switching means (second supplying step) or the exclusive OR gating means (exclusive OR gating step) is employed. Alternatively, either the inverting means (inverting step) and the switching means (second supplying step) or the exclusive OR gating means (exclusive OR gating step, otherwise, the phase advancing means (phase advancing step) and the switching means (second supplying step) are employed. Therefore, the increase in the additionally provided circuit scale (processing step) can be suppressed to the

minimum circuit scale, and thus, such an arrangement may be suitably formed in an integrated circuit.

Moreover, in accordance with the present invention, when the communication data is transmitted/received by switching a plurality of frequency bands in response to the band switching signal, the discrete data of the frequency pattern component functioning as a base is saved in the storage means (by storing step); the address generating means (address generating step) generates the address every preselected clock; the phase shift means (phase shift step) adds the predetermined number based upon the band switching signal to the address; the first analog converting means (first analog converting step) analog-converts the data which is read out by addressing the data saved in the storage means (storing step) based on the address outputted from the address generating means (address generating step) to thereby supply the analog-converted data to one set of the first quadrature mixer and the second quadrature mixer. The first quadrature mixer converts either the reception signal or the reception intermediate frequency signal into the reception baseband signal.

The second quadrature mixer converts the transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal. Also, the second analog converting means (second analog converting step) analog-converts the data which is read out by addressing data saved in the storage means (storage step) in response to the output of the phase shift

means (phase shift step), and thereafter supplies the analog-converted data to either the other mixer of the first quadrature mixers and the second quadrature mixer. As a consequence, the structural element (processing step) additionally provided so as

5 to execute the correct modulating/demodulating process operations in accordance with the band switching control by the band switching signal may be realized by the DDS (Direct Digital Synthesizer) and the DSP (Digital Signal Processor) and the like, which are additionally provided in the transmission system and  
10 the reception system. As a result, the increase in the additionally provided circuit scale (processing step) can be suppressed to the minimum circuit scale. Therefore, such an arrangement may be suitably formed in an integrated circuit.

Furthermore, the deteriorations of the reception baseband signal  
15 and the transmission baseband signal can be avoided, although conventionally the transmission baseband signal and the reception baseband signal are directly processed to invert the code polarities of the quadrature components.

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WHAT IS CLAIMED IS:

1. A multiband data communication apparatus which receives signals by switching a plurality of frequency bands in response to a band switching signal, said multiband data  
5 communication apparatus comprising

quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, said quadrature demodulating means including:

10 a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal;

local oscillating means for producing a local oscillation signal; and

15 phase shifting means for shifting a phase of said local oscillation signal based upon said band switching signal to thereby supply the phase-shifted local oscillation signal to said first quadrature mixers.

20 2. A multiband data communication apparatus which transmits signals by switching a plurality of frequency band in response to a band switching signal, said mutliband data communication apparatus comprising:

quadrature modulating means for converting a quadrature  
25 transmission baseband signal into either a transmission signal

or a transmission intermediate frequency signal, said quadrature modulating means including:

a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal  
5 or the transmission intermediate frequency signal;

local oscillating means for producing a local oscillation signal; and

phase shifting means for shifting a phase of said local oscillation signal based upon said band switching signal to  
10 thereby supply the phase-shifted local oscillation signal to said second quadrature mixers.

3. A multiband data communication apparatus comprising:

15 quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal;

quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal  
20 into a quadrature reception baseband signal; and

local oscillation signal producing means for supplying a local oscillation signal to both said quadrature modulating means and said quadrature demodulating means, for transmitting/receiving by switching a plurality of frequency  
25 bands in response to a band switching signal,

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wherein said quadrature demodulating means includes a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal;

5           said quadrature modulating means includes a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and

          said local oscillation signal producing means includes  
10   local oscillating means for producing a local oscillation signal, and phase shifting means for shifting a phase of said local oscillation signal based upon said band switching signal to thereby supply the phase-shifted local oscillation signal to said first quadrature mixers and said second quadrature mixers.

15

          4.    A multiband data communication apparatus as claimed in claim 1, 2, or 3, wherein said phase shifting means supplies a signal obtained by shifting the phase of said local oscillation signal by  $\pi/2$  to one of said first quadrature mixers  
20   and said second quadrature mixers, while said phase shifting means supplies one of said local oscillation signal and a signal obtained by inverting a code of said local oscillation signal to the other of said first quadrature mixers and said second quadrature mixers in response to said band switching signal.

25

5.    A multiband data communication apparatus as

claimed in claim 1, 2, or 3, wherein said phase shifting means supplies said local oscillation signal to one of said first quadrature mixers and said second quadrature mixers, while said phase shifting means supplies one of a signal obtained by shifting the phase of said local oscillation signal by  $\pi/2$  and a signal obtained by shifting the phase of said local oscillation signal by  $\pi/2$  and by inverting said phase-shifted local oscillation signal to the other mixer of said first quadrature mixers and said second quadrature mixers in response to said band switching signal.

6. A multiband data communication apparatus as claimed in claim 1, 2, or 3, wherein phase shifting means supplies said local oscillation signal to one of said first quadrature mixers and said second quadrature mixers, while said phase shifting means supplied one of a signal obtained by delaying the phase of said local oscillation signal by  $\pi/2$  and a signal obtained by advancing the phase of said local oscillation signal by  $\pi/2$  to the other of said first quadrature mixers and said second quadrature mixers in response to said band switching signal.

7. A multiband data communication apparatus which receives signals by switching a plurality of frequency bands in response to a band switching signal, said multiband data communication apparatus comprising:

quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, said quadrature demodulating means including:

- 5           a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal;

          storage means for saving thereinto discrete data of a frequency pattern component functioning as a base;

- 10          address generating means for generating an address every preselected clock;

          phase shift means for adding a predetermined number based upon said band switching signal to said address;

          first analog converting means for analog-converting data

- 15       which is read out by addressing said storage means based on the address outputted from said address generating means to thereby supply the analog-converted data to one of said first quadrature mixers; and

- second analog converting means for analog-converting  
20       data which is read out by addressing said storage means based on the output of said phase shift means to thereby supply the analog-converted data to the other of said first quadrature mixers.

- 25           8.    A multiband data communication apparatus which



quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, said quadrature modulating means including:

storage means for saving therein discrete data of a frequency pattern component functioning as a base;

phase shift means for adding a predetermined number based upon said band switching signal to said address;

second analog converting means for analog-converting data which is read out by addressing said storage means, based on the output of said phase shift means to thereby supply the analog-converted data to the other of said second quadrature

mixers.

9. A multiband data communication apparatus comprising:

5 quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal;

quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal  
10 into a quadrature reception baseband signal; and

local signal producing means for supplying a local oscillation signal to both said quadrature modulating means and said quadrature demodulating means, for transmitting/receiving by switching a plurality of frequency bands in response to a band  
15 switching signal,

wherein: said quadrature demodulating means includes a pair of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal;

20 said quadrature modulating means includes a pair of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and

said local oscillation signal producing means includes  
25 storage means for saving therein discrete data of a frequency

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pattern component functioning as a base; address generating means for generating an address every preselected clock; phase shift means for adding a predetermined number based upon said band switching signal to said address; first analog converting means  
5 for analog-converting data which is read out by addressing said storage means based on the address outputted from said address generating means to thereby supply the analog-converted data to one of said first quadrature mixers; and second analog converting means for analog-converting data which is read out by addressing  
10 said storage means based on the output of said phase shift means to thereby supply the analog-converted data to the other of said first quadrature mixers.

10. A multiband data communication apparatus as  
15 claimed in claim 7, 8, or 9, wherein either said quadrature modulating means or said local oscillation signal producing means includes:

clock generating means for generating a clock signal; and  
interval determining means for determining a clock  
20 interval used to read out data from said storage means so as to control the address generating operation of said address generating means.

11. A communication method of a multiband data  
25 communication apparatus including quadrature demodulating means

for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, for receiving by switching a plurality of frequency bands in response to a band switching signal, said

5 communication method comprising the steps of:

producing a local oscillation signal;

shifting a phase of said local oscillation signal in response to said band switching signal to thereby supply the phase-shifted local oscillation signal to a first quadrature

10 mixer for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal.

12. A communication method of a multiband data communication apparatus including quadrature modulating means  
15 for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, for transmitting by switching a plurality of frequency band in response to a band switching signal, said communication method comprising the steps of:

20 producing a local oscillation signal; and

shifting a phase of said local oscillation signal in response to said band switching signal to thereby supply the phase-shifted local oscillation signal to a second quadrature mixer for converting a transmission baseband signal into either

25 the transmission signal or the transmission intermediate

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frequency signal.

13. A communication method of a multiband data communication apparatus including quadrature modulating means  
5 for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal; and quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal;  
10 which transmits and receives signals by switching a plurality of frequency bands in response to a band switching signal, said communication method comprising the steps of:
- producing a local oscillation signal; and
  - shifting a phase of said local oscillation signal in  
15 response to the band switching signal to thereby supply the phase-shifted local oscillation signal to one of a first quadrature mixer and a second quadrature mixer, said first quadrature mixer converting either the reception signal or the reception intermediate frequency signal into a reception baseband  
20 signal, and said second quadrature mixer converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal.

14. A communication method of a multiband data  
25 communication apparatus as claimed in claim 11, 12, or 13, wherein

said phase shifting step includes:

a first supplying step for supplying a signal which is obtained by shifting the phase of said local oscillation signal by  $\pi/2$  to one of said first quadrature mixer and said second

5 quadrature mixer;

an inverting step for inverting a code of said local oscillation signal; and

a second supplying step for supplying one of said local oscillation signal and the output signal of said inverting step  
10 to the other of said first quadrature mixer and said second quadrature mixer in response to said band switching signal.

15. A communication method of a multiband data communication apparatus as claimed in claim 11, 12, or 13, wherein  
15 said phase shifting step includes:

a first supplying step for supplying said local oscillation signal to one of said first quadrature mixer and said second quadrature mixer;

a phase shifting step for shifting the phase of said local  
20 oscillation signal by  $\pi/2$ ;

an inverting step for inverting a code of said output signal of said phase shifting step; and

a second supplying step for supplying one of said output signal of said phase shifting step and the output signal of said  
25 inverting step to the other of said first quadrature mixer and

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said second quadrature mixer in response to said band switching signal.

16. A communication method of a multiband data communication apparatus as claimed in claim 11, 12, or 13, wherein said phase shifting step includes:

a first supplying step for supplying said local oscillation signal to one of said first quadrature mixer and said second quadrature mixer;

10 a phase delaying step for delaying the phase of said local oscillation signal by  $\pi/2$ ;

a phase advancing step for advancing the phase of said local oscillation signal by  $\pi/2$ ; and

15 a second supplying step for supplying one of the output signal of said phase delaying step and the output signal of said phase advancing step to the other of said first quadrature mixer and said second quadrature mixer in response to said band switching signal.

20 17. A communication method of a multiband data communication apparatus including quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal, for receiving by switching a plurality of  
25 frequency bands in response to a band switching signal, said

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a storing step for saving therein discrete data of a frequency pattern component functioning as a base;

a phase shifting step for adding a predetermined number based upon said band switching signal to said address;

a first analog converting step for analog-converting data which is read out by addressing said storing step based on the address outputted from said address generating step to thereby supply the analog-converted data to one of first quadrature mixers for converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal; and

a second analog converting step for analog-converting data which is read out by addressing said storing step based on the output of said phase shifting step to thereby supply the analog-converted data to the other of said first quadrature mixers.

18. A communication method of a multiband data communication apparatus including quadrature modulating means for converting a quadrature transmission baseband signal into either a transmission signal or a transmission intermediate frequency signal, for transmitting by switching a plurality of



frequency band in response to a band switching signal, said communication method comprising:

a storing step for saving thereinto discrete data of a frequency pattern component functioning as a base;

5 an address generating step for generating an address every preselected clock;

a phase shifting step for adding a predetermined number based upon said band switching signal to said address;

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10 a first analog converting step for analog-converting data which is read out by addressing said storing step based on the address outputted from said address generating step to thereby supply the analog-converted data to one of second quadrature mixers for converting a transmission baseband signal into either the transmission signal or the transmission intermediate  
15 frequency signal; and

a second analog converting step for analog-converting data which is read out by addressing said storing step based on the output of said phase shifting step to thereby supply the analog-converted data to the other of said second quadrature  
20 mixers.

19. A communication method of a multiband data communication apparatus including quadrature modulating means for converting a quadrature transmission baseband signal into  
25 either a transmission signal or a transmission intermediate

frequency signal; and quadrature demodulating means for converting either a reception signal or a reception intermediate frequency signal into a quadrature reception baseband signal; and for transmitting/receiving by switching a plurality of frequency bands in response to a band switching signal, said communication method comprising:

a storing step for saving thereinto discrete data of a frequency pattern component functioning as a base;

an address generating step for generating an address every preselected clock;

a phase shifting step for adding a predetermined number based upon said band switching signal to said address;

a first analog converting step for analog-converting data which is read out by addressing said storing step based on the address outputted from said address generating step to thereby supply the analog-converted data to one of a first quadrature mixer and a second quadrature mixer, said first quadrature mixer converting either the reception signal or the reception intermediate frequency signal into a reception baseband signal, and a second quadrature mixer converting a transmission baseband signal into either the transmission signal or the transmission intermediate frequency signal; and

a second analog converting step for analog-converting data which is read out by addressing said storing step based on the output of said phase shifting step to thereby supply the

analog-converted data to the other of said first quadrature mixer and said second quadrature mixer.

20. A storage medium for storing therein a computer  
5 readable program used to execute the communication method of the  
multiband data communication apparatus as recited in claim 11,  
12, 13, 14, 15, 16, 17, 18, or 19.

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### ABSTRACT OF DISCLOSURE

A quadrature demodulator 408' and a quadrature modulator 908' convert a reception intermediate frequency signal 151 into reception baseband signals 157 and 158, and also convert transmission baseband signals 657 and 658 into a transmission intermediate frequency signal 651, respectively. While local oscillation signals having frequencies suitable for the respective bands are outputted from a commonly used local oscillator 111, such a local oscillation signal obtained by shifting a phase thereof  $\pi/2$  by a phase shifter 412 is supplied to one mixer of quadrature mixers 109 and 609, and such a signal obtained by inverting, or not inverting the plurality of the local oscillation signal by an exclusive OR gate circuit 413 in response to a band switching signal 153 is supplied to the other mixer of quadrature mixers 110 and 610.





FIG. 3

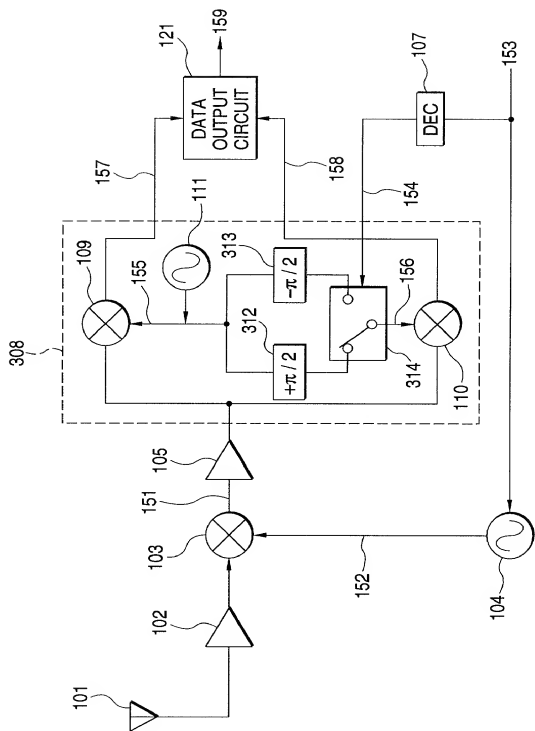






FIG. 5

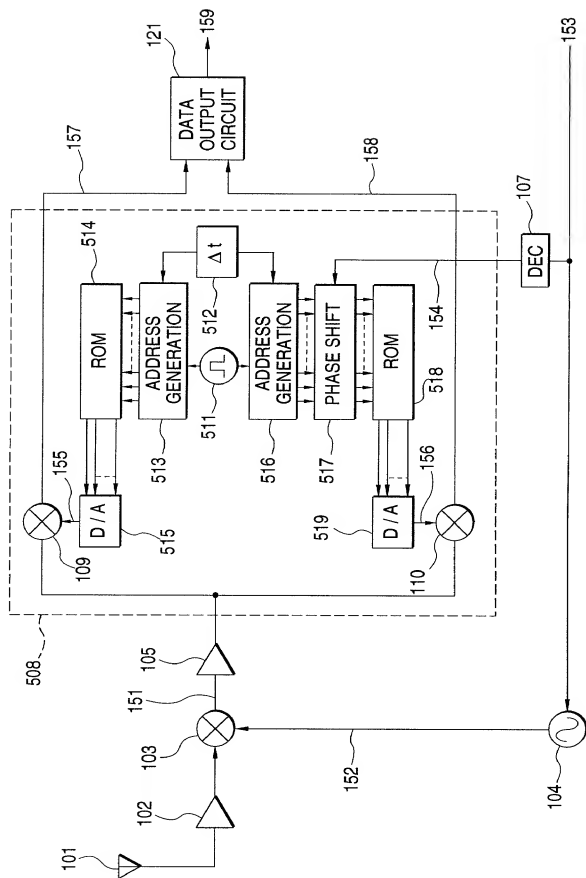


FIG. 6

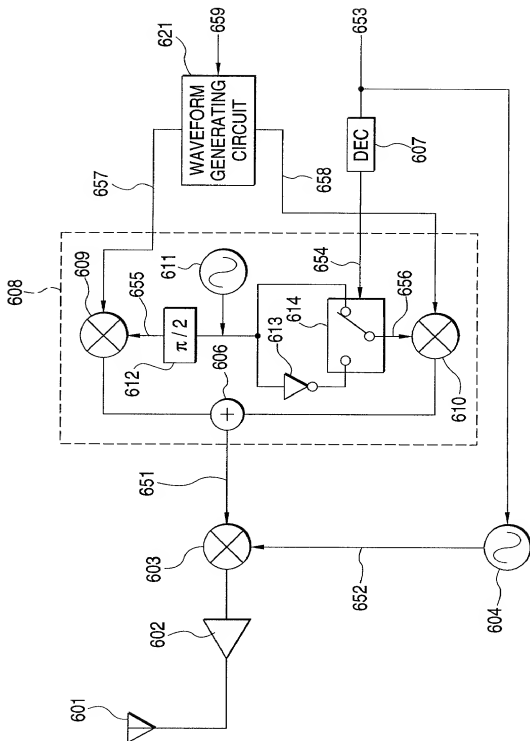


FIG. 7

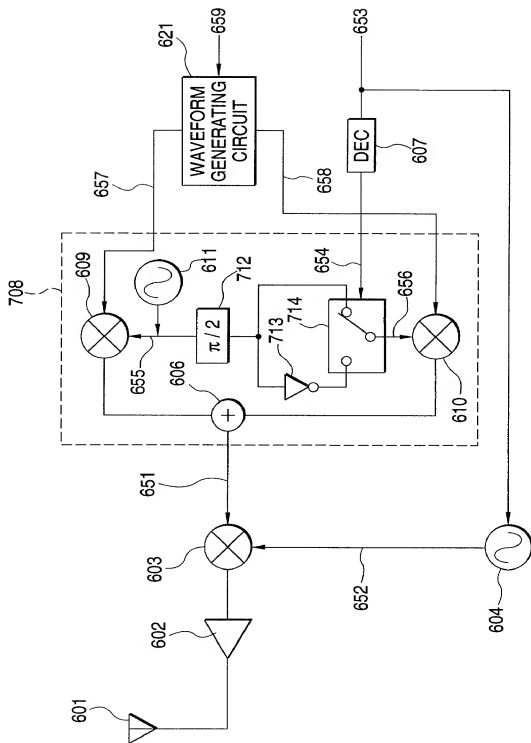
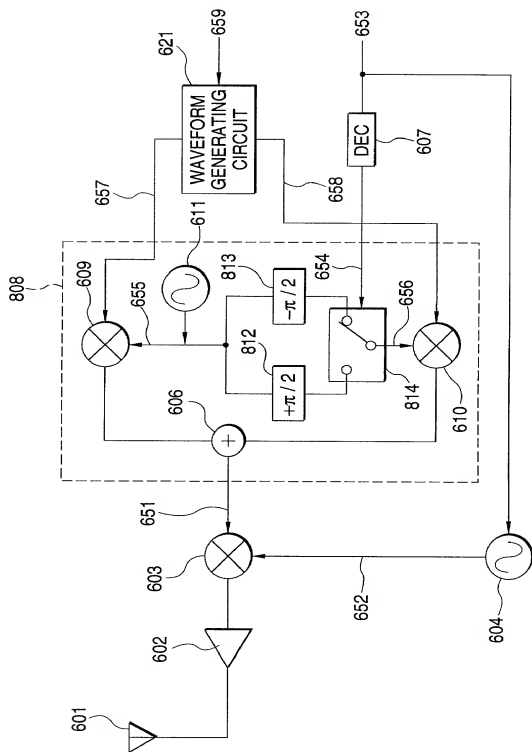


FIG. 8



**FIG. 9**

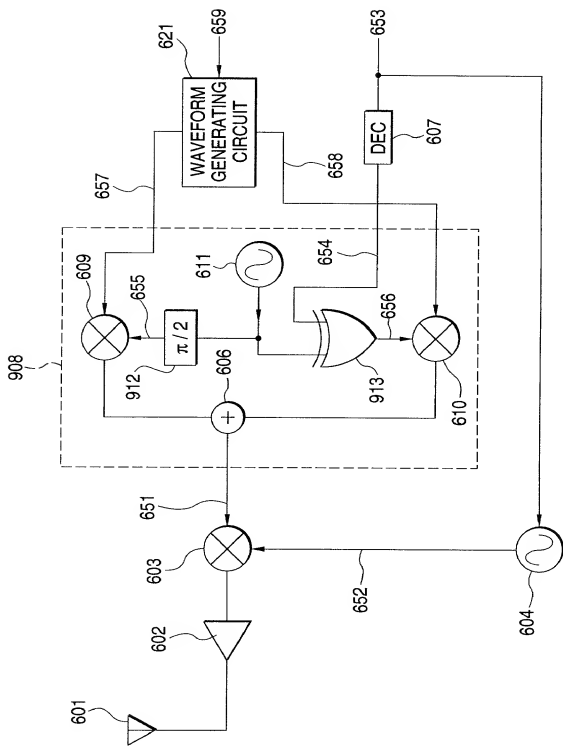


FIG. 10

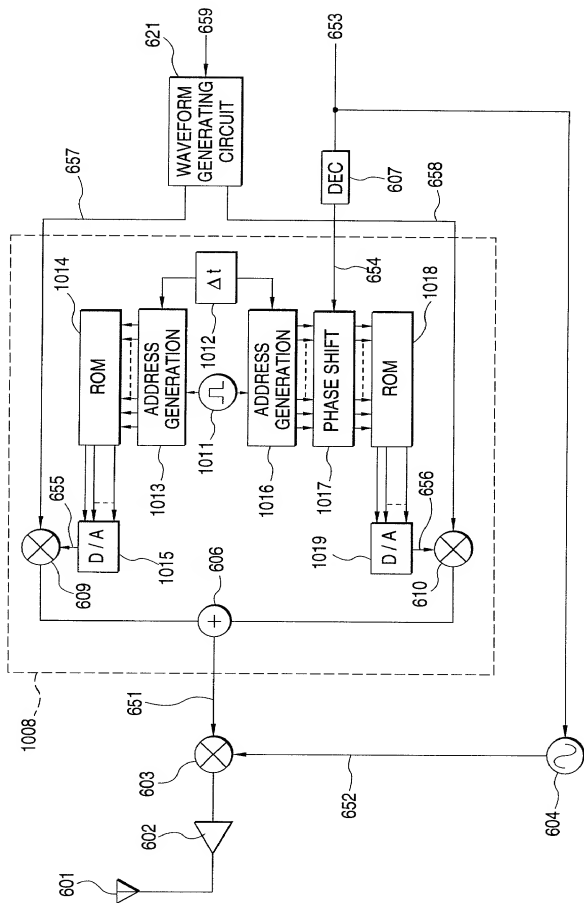


FIG. 11

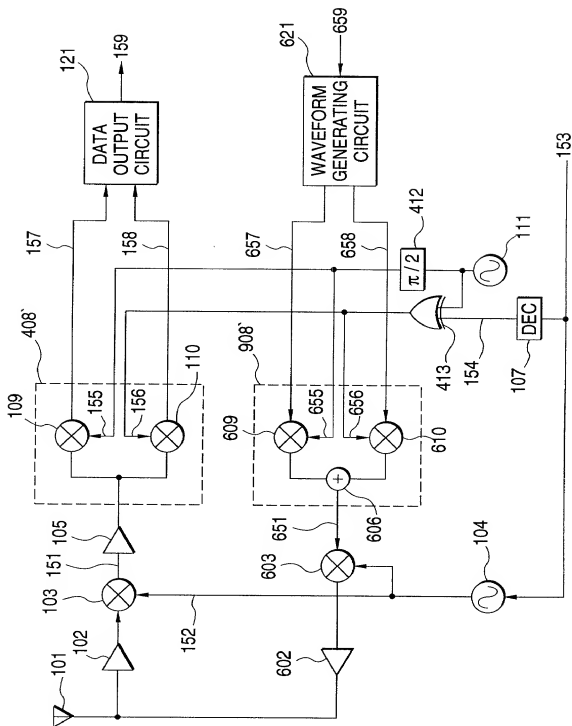
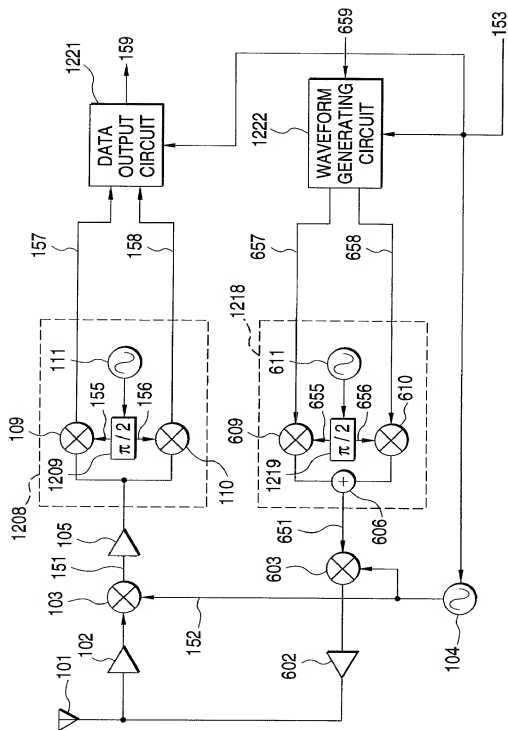


FIG. 12





**COMBINED DECLARATION AND POWER OF ATTORNEY  
IN ORIGINAL APPLICATION**

(Sole or Joint - Foreign)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe that I am the original, first and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

MULTIBAND DATA COMMUNICATION APPARATUS,  
COMMUNICATION METHOD OF MULTIBAND DATA,  
COMMUNICATION APPARATUS, AND STORAGE MEDIUM,

the specification of which

  X   is attached hereto.

\_\_\_\_\_ was filed on \_\_\_\_\_ as application Serial No. \_\_\_\_\_ and  
was amended on \_\_\_\_\_.

I hereby state that I have reviewed and understand the content of the above-identified specification, including the claims (Pearne, Gordon, McCoy & Granger Docket No. 32430 ), as amended by any amendment referred to above. I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119, of any foreign application(s) for patent or inventor's certificate listed below, and have also identified below any foreign applications for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Country _____	Application Number _____	Filing Date (day/month/year) _____	Priority Claimed?	
			Yes	No
Japan	Pat. Hei. 11-82514	25/March/1999	XX	

I hereby designate the following as my mailing address and telephone number:

Pearne, Gordon, McCoy & Granger  
1200 Leader Building  
Cleveland, Ohio 44114  
(216) 579-1700

and appoint each of the following as my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith:

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William C. McCoy, Reg. No. 16885  
Richard H. Dickinson, Jr., Reg. No. 18622  
Thomas P. Schiller, Reg. No. 20677  
David B. Deioma, Reg. No. 22841  
Joseph J. Corso, Reg. No. 25845  
Howard G. Shimola, Reg. No. 26232  
Jeffrey J. Sopko, Reg. No. 27676

John P. Murtaugh, Reg. No. 34226  
James M. Moore, Reg. No. 32923  
David E. Spaw, Reg. No. 34732  
Michael W. Garvey, Reg. No. 35878  
Mark E. Bandy, Reg. No. 35788  
Paul R. Katterle, Reg. No. 36563  
Richard M. Mescher, Reg. No. 38242

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

(1) Inventor (sole or joint): Yasuaki NAMURA

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Signature Yasuaki Namura

Date February 17, 2000

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Kanagawa, Japan